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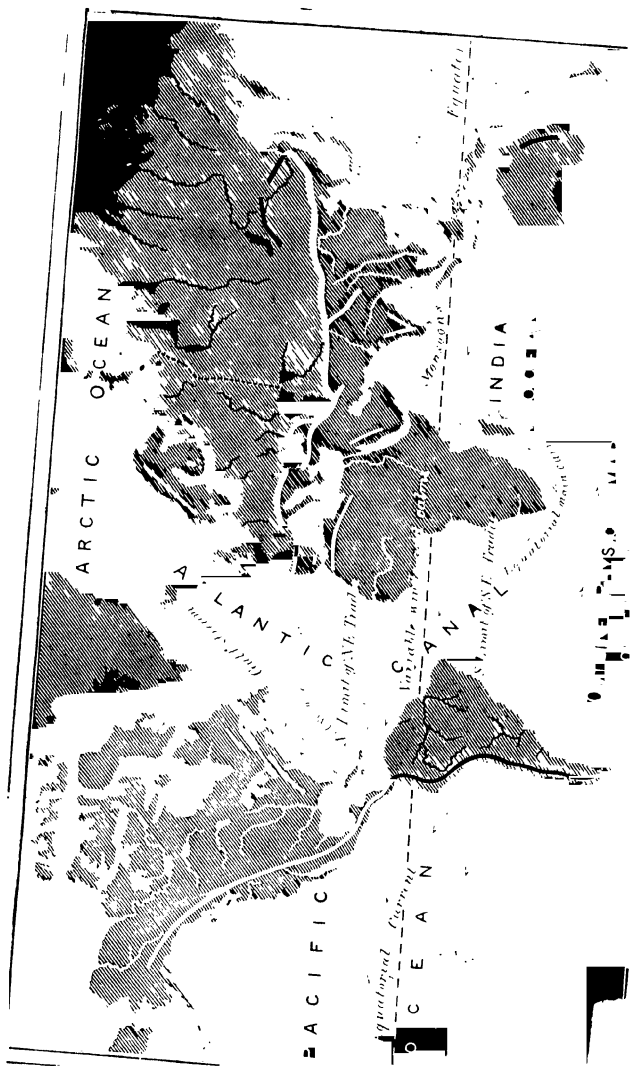
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THE
WORLD WE LIVE IN.



THE
WORLD WE LIVE

OR,

FIRST LESSONS

IN

PHYSICAL GEOGRAPHY.

BY

D. T. ANSTED, M.A., F.R.S.,

ETC.

ELEVENTH THOUSAND.

FOR THE USE OF SCHOOLS AND STUDENTS.

LONDON :

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INTRODUCTORY NOTICE.

THE present work is intended as a short and easy text-book for the use of students in the various science-schools throughout the United Kingdom. The number of students in Physical Geography is so large, and increases so rapidly, that it is unnecessary to urge the great value of this department of science as an educational subject. It remains only that the instruction should be sound, and that the subject should be rendered as simple and easy as its nature admits.

It must be needless to point out that larger treatises on the subject are not superseded by this class-book. The present outline is a mere abstract, and when its contents are mastered, the advanced student must attack more complete works. There are few subjects more generally interesting, more definite, and more useful than Physical Geography, and few are better fitted for class instruction. At the same time, it is a subject in which an intelligent and energetic person can, in case of need, master the difficulties alone, and teach himself all that is to be known by books.

To render the work more generally useful, both to Teachers and Students, an outline-map and some illustrations are given in the present edition. There is also a full Glossary.

The Examination Papers, forming an Appendix in the last edition, are now published as part of a separate volume, under the title of "2,000 Examination Questions in Physical Geography."

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DESCRIPTION OF THE MAP.

IN this Map the student will be able to notice the general shape and distribution of land, the peculiar form of the Atlantic Ocean, and the general arrangement of the great islands. The great geographical axes of the two continents, the position of some of the chief rivers and lakes, and the direction of a few of the marine currents are also indicated. The limits of the trade winds, and of some of the other principal wind storms, are marked. More than this has not been attempted ; and the scale of the Map does not admit of its being regarded as more than a diagram.

FIRST LESSONS

IN

PHYSICAL GEOGRAPHY.

CHAPTER I.

THE EARTH AND ITS HISTORY.

It is very desirable that those who live on any part of the earth should know something of their own country, and also that they should be able to compare its climate and productions with those of other countries. To an Englishman, who lives on an island favoured with a mild but rather damp climate, who finds growing and living around him a certain limited variety of plants and animals, and who knows that comparatively few of these are native to the soil, but have at various times been introduced from abroad (where, however, some of them are not produced to such perfection as with us), it is especially useful to know what is the state of things in these matters elsewhere. His attention is thus directed to other lands at a distance, whether in Europe, Asia, America, Africa, or Australia. He lives by commerce with these distant lands. He obtains their products and supplies them with much that they need. In all of them he has important interests. His travels for

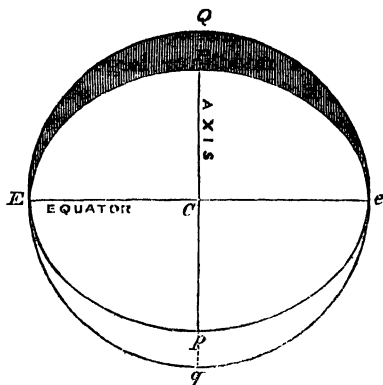
amusement or on business, his trade, and the many communications he is forced to make, all render it desirable that he should know as much about them as possible. Their climate, soil, and productions differ so greatly, and their inhabitants are so dependent on these and on geographical position, that the cause and extent of these differences become an inquiry worthy of careful research.

This kind of research is called Physical Geography. It is not the same thing as geography in the old sense of the word ; that branch of knowledge is now called Descriptive or Political Geography, and has reference chiefly to the artificial divisions introduced by man, and to the towns and villages built by him. It refers to rivers and seas, lofty mountain chains, vast plains, deserts, and valleys, but only so far as they afford means of communication, interrupt progress, affect trade, and separate human families.

By Physical geography we may understand the various natural relations of cause and effect that belong to the surface of our globe. It describes the distribution of land and sea, and, so far as can be determined, the causes and results of this distribution. It treats of the properties of water, and the extent of surface covered by it ; the depth of the ocean, the tides and currents, and the nature of the sea-bottom. It considers the nature and extent of the air that floats over the general surface ; it discusses and explains the mutual influence of air and water, the nature of climate, and the circulation of water through the air, and upon and beneath the earth. Besides these important points, it includes all that relates to the distribution of life and other phenomena, some of which we shall have occasion to allude

to in these pages, and others that must for the present be deferred. It is enough to show now how much Physical geography teaches concerning many matters that seem very simple, but that greatly influence the earth as a habitation.

FIG. 1.—FIGURE OF THE EARTH.



E e.—The equatorial axis. *P, p.*—The poles. (*P p.*—The polar axis.
C.—The centre. *P q.*—The compression.

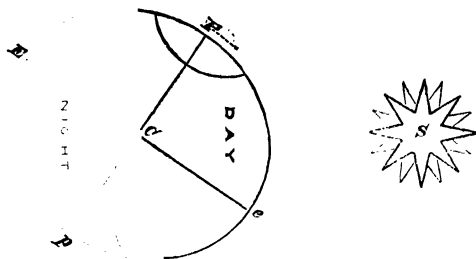
The earth is a slightly-flattened globe or ball, shaped something like an orange, and constantly spinning round like a humming-top. The peg of the top continued to form the stick on which it is wound up, to represent what is called the axis of the earth, and the two ends are the poles. The earth revolves round its axis in the way that the top revolves round the stick. The line on the earth corresponding to that round the middle or largest part of the top is called the equator. There is a small bulge at the equator, and flattening at the two

poles. All this will be better understood by referring to the diagram, which represents the flat surface of the globe when cut in half through the middle. P, p are the poles, and the line Pp the polar axis. Ee is the equatorial axis or equator. $EQeq$ the half of a corresponding globe unflattened. Pq is called the compression. The time taken for the earth to spin once round on its axis is a day, or twenty-four hours; and as the length of a line stretched round the earth in its middle or largest part is about 24,000 miles, it is clear that an object placed on the equator, and moving with the earth, proceeds at the rate of 1,000 miles an hour. If we imagine a number of rings, of different sizes, dropped on the top which represents the earth, while it is spinning, the largest will go nearest the middle or equator, and the smallest although parallel to it, will be nearer the point where the stick comes through the top, which we have called the pole. The distance round each ring is the distance travelled by anything placed upon it, during one turn of the top. The distance is less as the ring is smaller, but the time of running is the same. The rate is therefore smaller. On the earth also, in proportion as an observer is more distant from the equator, the number of miles he is carried per hour is lessened. At the poles there is no distance travelled at all.

The earth's rotation on its axis is the cause of day and night; for as light proceeds from the sun, the half of the earth exposed at any time is lighted, while the other half is dark. But as the earth turns on its axis in twenty-four hours, every part in succession is passed before the sun, and would be lighted daily if it were not for the fact that there is

a twist in the position of the earth, which must be explained in another place.

FIG. 2.—ILLUSTRATIONS OF DAY AND NIGHT.



S.—The sun. Pp.—The polar axis, or axis of rotation.
Ec.—Equatorial axis.

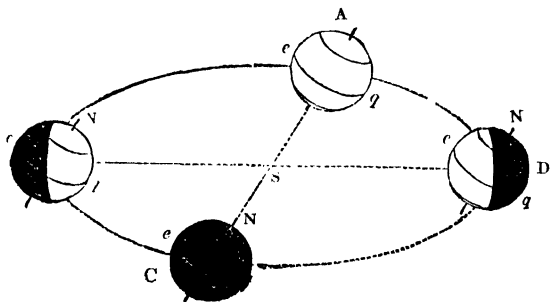
But the earth, besides spinning round like a top, also moves round the sun. If a child were to spin a top while seated in a merry-go-round at a fair, the movement of a fly or other small insect on the top would nearly represent the movements of a person or place on the earth. Such motion is performed entirely without any sense of motion to him, and even without his knowledge, and without at all affecting his place in reference to other objects near him on the earth.

We need not stop here to consider the complications of these movements, but it is very desirable that every one should have an idea of their general nature before beginning to study Physical Geography. The sun is represented in our rough illustration by the machinery that sets the merry-go-round in motion. The distance of the sun from the earth varies from time to time, but averages about $91\frac{1}{2}$ millions of miles, and the time taken by the earth to go once

round is one year, or 365 days. The earth, therefore, moves round the sun at the rate of about 65,500 miles an hour, or more than 1,000 miles a minute. This vast speed is altogether unfelt, and the whole movement is consistent with perfect relative repose in the individual dwelling on the earth's surface.

The seasons are the result of the inclination of the earth's orbit to the imaginary plane passing through the centres of the earth and sun, in which the earth revolves. This plane is represented in perspective in Fig. 3, where the position of the earth is shown at B, the spring season (vernal equinox); A, summer (summer solstice); D, autumn (autumnal equinox); and C, winter (winter solstice), respectively. The darkly-shaded part of the earth, re-

FIG. 3.—THE SEASONS.



N.—The north pole of the earth. S.—The sun. eq.—The earth's equator.
A, B, C, D,—Different positions of the earth in its orbit.

presents the part not illuminated by the sun, and therefore not warmed. When the earth is at B or D, the days and nights are equal all over the world. At A, the days are longer than the nights in the northern hemisphere, and near the north pole there

is no night. At D, they are shorter in the northern hemisphere, and near the north pole there is no day. The converse is the case of the southern hemisphere.

The earth is accompanied by the moon, which moves round its axis like the earth, and round the earth as the earth does round the sun. The moon reflects light from the sun, and by its nearness, in proportion to the sun, it exercises considerable influence. It is the chief cause of the tides of the ocean.

It is impossible that the matter of which the earth, the sun, and the moon are composed should perform all these motions, keeping in their respective places in space from year to year and century to century, without some powerful ruling cause. We do not here speak of the great First Cause, to whom their original creation is due, but of those laws imposed on all matter, in obedience to which the great system is upheld. Nor is it meant when we thus talk of natural laws that there is any very traceable resemblance in them to those laws which are contrived to regulate men's morals or punish those guilty of offence. The great laws of nature are not of this kind. A law is understood to involve an obligation to obedience, or submission; the expression is used because there appear to be certain results following without fail certain causes; so that the result, being invariable, is due to an obligation or necessity. Thus it is a fact of universal experience that if one mass of matter in motion come in contact with another, whether both are in motion or one at rest, motion appears to be checked or stopped. The motion is not really destroyed, but being changed into something else, and not recognized, it is lost sight of. If we trace it carefully we shall find that this something is generally heat, and

Again, when force is suddenly checked and converted into heat, it tends the other way, and keeps the particles or atoms of each body asunder. This is sometimes called repulsion. There are thus two modes in which force is exercised in nature : one is by attraction, or bringing together atoms or groups of atoms forming solid or fluid bodies ; the other is by repulsion, forcing apart or separating the atoms once brought together. If one alone should act exclusively, so that the other could not act, the order of nature would be at an end. If there were no force of gravitation, the atoms would keep asunder, and never form a liquid or solid at all. If there were no heat, the atoms must become compacted into one mass, without interval. As far as we know these are impossible conditions, and the two forms of force, gravitation and heat, always act and are always displacing and replacing each other. In the first establishment

of the interchange of these forms of force appears to have consisted the great act of creation, the formation of a system governed by certain fundamental principles. These principles are further illustrations of what is meant by the laws of nature.

steam in its properties, except that it does not condense into fluid by any known amount of cold. Such mixed gases, in the proportion in which they occur on the earth's surface, we call air, or "the atmosphere," or sometimes "atmospheric air." The atmosphere forms a veil or shroud, entirely covering earth and water to a distance of many miles from the surface. It is of such a nature that many other substances can exist in it, and apparently form part of it, though really independently of it. In this sense it is said to contain vapour of water, the various gases that arise from the changes of living beings on the earth, the poison derived from decaying animal and vegetable matter, the odours of flowers, and many other substances, some solid, some fluid, and some gaseous. But the atmosphere is an important and material substance, though neither to be seen nor touched. This may be proved easily by removing it from any well-enclosed space, as from a copper box with a very thin cover. The pressure may then be measured by

the depression of the surface of the cover, if it is sufficiently elastic; and on this principle is constructed the instrument called "the aneroid barometer." The common barometer measures the weight or pressure of the air in a somewhat similar way, by the use of the fluid metal mercury, held in a long glass tube, closed at one end, and placed with the open end downwards in a small cup of mercury. The tube being longer than sufficient to counterbalance the whole weight of a column of the atmosphere of the same size as the column of mercury, the fluid descends in the tube till the two weights exactly balance each other. As the air is constantly changing in pressure or weight in our climate, the thin cover of the box and the mercury in the tube are constantly rising or falling, and the amount may be measured. In some countries, where the pressure of the air varies very little, the barometer rarely indicates any change. In other countries a change to the extent of one-thirtieth part is not unusual. Sometimes the change is much greater.

Besides the three familiar conditions of solid, liquid, and gaseous matter (or of earth, water, and air), there are other indications of the activity of matter, other forms in which force presents itself. Light as well as heat is a form of force. Electricity and magnetism are forms of force. Chemical action is a form of force; and even life itself, or vital action, so far as it can be understood, and so far as it is connected with and dependent upon matter, is another form of the same ever-present force. We are not here speaking of intelligence, but simply of life in its relations with matter.

The actual elements, or those substances in nature

which appear to be absolutely simple, and are not made up of others, are for the most part only to be obtained with great difficulty by the chemist in his laboratory. They rarely exist in nature unmixed with other substances. Many of them, however, are found in the earth in a nearly pure state. Such are sulphur, carbon (the diamond, and some kinds of coal), gold, silver, copper, and a few other metals. The old "four elements"—earth, air, fire, and water, have long been known to be either compounds, as earth, air, and water, or indications of the action of force, as fire. But they remain familiar and convenient expressions representing great classes of facts, with which the student of Physical geography must become acquainted. We may with advantage make use of them, follow them up, and endeavour to make out the meaning and intention of nature in the distribution of them on the earth.

The solid earth is a much more complicated mass than either water or air. These latter, though compounds, are composed of only two elements. The earth is composed of many. Thus, the stony and sandy masses of various kinds, among which the metals are occasionally met with, generally contain three or more elements. Limestone, sandstone, clay, granite, and slate are the familiar names of these masses. They are all, even in their purest state, compounds, in which a peculiar gas called *oxygen* is present in very considerable quantity. This gas also forms a fifth part of the air, and half the water. It has a great tendency to mix with almost all substances in nature, except some of the metals. It is, therefore, one of the most abundant substances in the outer crust of the globe.

There are two other gases whose names require to be known. Four measures of *nitrogen* mixed with one of oxygen, form the atmospheric air, and two measures of *hydrogen* with one of oxygen, when chemically combined, become water. *Chlorine* is another important gas, but it is not abundant, except in combination with sodium as common salt.

Mixture and combination are, however, very different. The first is merely mechanical, and involves little change. Sugar and salt mix with water, and gases, such as oxygen and nitrogen, in certain proportions, may mix in the same manner. The mixture, though different from either, has none of the properties of an original substance or element. On the other hand, when oxygen and hydrogen combine to form water, the result is almost a new element. Oxygen and nitrogen combined form a strong acid. So again chlorine, a gas, and the metal called sodium, combine to form common salt, a substance totally different in every respect from its elements.

Besides those already mentioned, it is well that the student of Physical geography should know at least the names of a few other materials of which the earth's crust is chiefly made up. *Carbon*, already named, and found in a state almost pure in the diamond and in some kinds of stone coal, is an element also of extreme importance, as present and almost essential in all forms of life, whether vegetable or animal. Wood consists of little else, and flesh contains a large proportion. *Silica* is the substance from which sand and all the varieties of sandstone are obtained. *Alumina* serves the same purpose for clay. Both are combinations, but both are so nearly like elements in their permanence and

in their power of combining with other compounds, or with other elements, that they are much better known than the elements from which they are derived. *Soda* and *Potash* are other examples of a similar kind, obtained from the metals *Sodium* and *Potassium*, which, however, cannot remain without change in a moist atmosphere. *Phosphorus* is an important substance, and with this and some of the familiar metals the list closes.

Among the forms of force commonly spoken of in all references to climate and the state of the air, electricity, galvanism, and magnetism are the most important. That friction, or the checking of motion by the coming together of two substances, sometimes produces electricity as well as heat is easily shown. Thus, when a stick of sealing-wax, or glass, is rubbed on a coat-sleeve, it becomes electric, and attracts paper or a feather. A piece of copper and a piece of gold, placed one on the upper side, the other on the under side of the tongue, produce a slight galvanic shock when brought to touch at one point. On the other hand, a current of electricity passed through a piece of soft iron converts it into a magnet. The electric telegraph is a practical result of long-continued inquiries and experiments with regard to this form of force. Electricity acts throughout the earth's surface, and is, beyond doubt, one of the most direct modes in which change in the distant centre of our system is communicated to each member. We must not at present do more than remind the student that a link of this kind exists, and that all nature is bound together by similar links, rendering the whole one great harmonious system.

Besides the shell or outer crust of the earth and

the various forms of matter and force belonging to it, there is also on its surface a vast variety and infinite succession of living beings. Of these there are two kinds—animal and vegetable. Of each there are some so simple in their construction that we can only find in them a peculiar fluid and a kind of skin as proof of life, and others so complicated that each individual consists of millions of minute parts, all separately living, but all mutually dependent on each other, and altogether forming one noble monument of creative power. Between these extremes we have every possible gradation. But these living beings endure but a short time. They die and become reduced to the elements of which they were built up, but not till, in some wonderful manner, there has been provided, through their agency, a succession of beings like themselves. Life is a great mystery. As far as it is a part of the system of creation it will probably be found to depend on a peculiar form of the universal force, governed and modified by those various forms—heat, electricity, and chemical action, already familiar. But the higher forms of life exhibit another quality or power, more difficult to explain, for they possess what is called a will as well as intelligence. Of this, which belongs to many animals, and of the yet higher and more subtle qualities of intellect and moral sense, we offer no explanation, for there is at present no clue whatever to their cause and mode of action.

The way is now open to the student to study the elements of Physical geography. He will have seen that all nature is related by close ties; that there is a system on which everything is planned and constructed; that a few simple substances in nature

produce by mixture and combination an almost infinite variety of compounds, of which some are used in large proportion, others in small quantity, but all of them assist in the great general result we see before us. They are governed, and changes in them produced, by the various forms of force. Some are attracted, others repelled ; but the ordinary passage of heat, light, and electricity constantly goes on through and among them.

But it must be remembered, as one of the laws most certain and most invariably acted on, that there is in nature no repose and no cessation of force. It is not only living matter that changes ; all the combinations of stone and rock are constantly though silently undergoing alteration. The earth has a long and complicated history. It was once thought that this history must involve occasional great revolutions, with long intervals of absolute repose. It is more likely that the revolutions are incessant, and the repose unknown. Hardly a moment—certainly not a year, a month, a day, or even an hour—passes without change ; and in the past, as at present, there is no evidence of there having been a time when change was not the law of nature. It has always been going on, both upon and within the earth, altering everything without exception, whether solid or fluid, and always tending to produce those peculiarities of structure that distinguish rocks long since formed from mud lately thrown down to the bottom of water, or molten material thrown up from a volcano.

The language of Physical geography, like that of all sciences, introduces some expressions not very familiar, and makes a peculiar and limited use of

certain common words and phrases. Some of these have been already explained, others will be explained as they are used. Before, however, proceeding further, it will be well to point out the exact meaning attached to certain words used in marking the position of objects on the earth; for it is not very easy, without some previous understanding, to describe where a certain point or a certain space is situated on a round ball such as we have described the earth to be.

In geography the terms North and South refer always to the same direction, and are determined by the pointing of the needle in the compass, by the position of the sun at noon, or by the position of certain stars. Of the two poles of the earth (*see* explanation of the term in p. 3), that which corresponds to the point where the stick of the humming-top joins the top is called north, and that which corresponds to the point where the peg joins it is called south. The part between the middle line, or equator, and the north pole is called the northern hemisphere (or half globe), and that between the equator and the south pole the southern hemisphere.

If a line be drawn on the surface from the north to the south pole, everything to the right hand of a person standing on it and looking north is called east, and everything to the left west. If such a line be drawn through the ocean between Europe and America, the land of Europe, Asia, and Africa will be in the Eastern hemisphere, and the land of America in the Western hemisphere. But if such a line were drawn through the Pacific Ocean, the contrary would be the case. Thus the terms north and south are positive and absolute, so far as the earth is con-

cerned; but east and west are relative, and depend on the position of the line from which we start. The fact that Europe and Asia were the dwelling-places of the early civilized nations is the only reason why the terms eastern and western are now practically limited to the countries east and west of the Atlantic Ocean.

Knowing the use of the terms north, south, east, and west, it is not difficult to understand what is meant by latitude and longitude. Latitude is the distance of any place from the equator, measured on a great circle passing through the place and the two poles, and is north or south, according as the place is in the northern or southern hemisphere. It is measured, as all circles are, by degrees, of which there are 360 in the whole circle, or 90 in the fourth part, between the equator and each pole. Longitude is the distance, east or west, from a similar great circle drawn through some important observatory, and is measured also by degrees, but on a circle parallel to the equator, and passing through the place. Every circle being divided into 360 equal degrees or parts, it will be easily understood that a point on the earth's surface cannot have more than 90 degrees of latitude, that representing the whole distance from the equator to the pole; but it may have any number up to 180 degrees of longitude. On the other hand, a degree of latitude is always of the same length (about $69\frac{1}{10}$ English miles), but the length of a degree of longitude varies with every degree of latitude. At the equator it is the same as that of a degree of latitude, and at the poles it is nothing. It is the 360th part of the length of the circle represented by the ring dropped

on the humming-top, in the illustration already referred to.

In the latitude of London ($51\frac{1}{2}$ degrees) the length of the degree of longitude is about $43\frac{1}{4}$ British statute miles.* At 60° the length is only one half as great as it is at the equator, or about $34\frac{1}{2}$ miles.

* The earth's circumference, or the length of a great circle drawn round it, is 21,856 British statute miles nearly, and therefore the degree of latitude is $\frac{21856}{360}$, or rather more than 69 miles. Geographers divide degrees into 60 equal parts or minutes. The sixtieth part of a degree of latitude, or of the minute of latitude, is often called a geographical mile. A nautical mile, or knot, is the same distance. It is a distance of 6,086 feet 9 inches, the statute mile being 5,280 feet. The distances in this work are given in statute miles.

CHAPTER II.

THE LAND.

THE land is that part of the solid crust of the earth that is not covered with the waters of the ocean. If the earth's surface were perfectly smooth the water would cover the whole to a certain depth, just as the air does, and there would be no land. Thus it is only in consequence of the existence of irregularities of the surface that there is any land or solid portion of the crust projecting above the general level of the water, and the amount of surface exposed is governed by the nature and extent of the irregularities. It must be evident that an uneven surface of the earth is necessary to its existence as the habitation of almost the whole of vegetable, and of a very large proportion of animal life. It is equally clear that the shape and depth of the sea-bottom decides the limits and the extent of the surface of the sea, and the position of the line separating land from water; for if the ocean were very much deeper than it is over a considerable part—that is if the bottom of the sea were sunk much lower than at present—the level of the whole ocean would be lowered, and many shallows become dry land. If shallow parts of the sea near shore were lifted up by earthquakes while such deep crevices were being formed, the effect would be still greater.

It would hardly be believed, without calculation, how very little difference in the form of the surface

of the land would make an enormous difference in the magnitude of the ocean without in any degree altering the quantity of water contained in it. And this is a very important matter, for on the mere form of a coast-line depends very much its fitness for the habitation of plants, animals, and man. It is the more important because there is every reason to suppose that in the history of the world there have been enormous changes in this respect, the water having perhaps at some time almost covered the whole surface, while at other times the land may have been much more extensive than it is now. At present, about one fourth part of the whole surface is above the sea-level.

Thus the actual shape of the land, the way in which its projecting points and irregular prominences extend, the form and extent of those smaller lands called islands, which approach, and sometimes almost touch, the main land, and which are only separated by shallow arms of the sea, and generally what is called "the distribution of the land," are objects of careful inquiry in Physical geography.

By referring to the map forming a frontispiece to the present volume, the student will recognize, rising above the level of the ocean, two very large tracts of connected land, one in the Eastern, the other in the Western hemisphere, and one smaller tract (Australia), which include almost the whole of the land. These large tracts are called *continents*. The great continents include, in the Eastern hemisphere, Europe, Asia, and Africa, which are often spoken of together as "the Old World," and to them Australia, though recently discovered, properly belongs. In the Western hemisphere they

include the two Americas (North and South), or "the New World," with a few outlying islands.

If the student will examine a globe, and will compare the northern and southern hemispheres, he will find a similar difference, the chief land being in the northern half.

At one time Europe, Asia, Africa, and America were called the four quarters or divisions of the earth; but if Europe, Asia, and Africa, which are all connected (Europe and Asia are altogether without an approach to natural separation, and Africa is only separated from Asia artificially by the canal through the Isthmus of Suez) are to be called two, America must be called two, and Australia is certainly another, for it is nearly as large as Europe. Thus there would be, according to this mode of estimating, five great masses of land, which would be thus described: (1) Europe and Asia, (2) Africa, (3) North America, (4) South America, and (5) Australia. These are natural divisions in the same sense as the division into two masses, the great continent and the American continent.

Besides these great masses or continents, a large number of fragments of land are called islands. These are separated by water from some main land, or the nearest continent. Many of them, and these are among the largest and the most important in every respect, are so placed in relation to the nearest continental lands that they appear to have once belonged to them, and to have been separated from them. Thus England is only separated from the main land of Europe by a comparatively narrow channel of no great depth. Islands of this kind are called "conti-

nental islands." There are others, such as many of the groups in the Pacific Ocean, which have no relation whatever to any continents that now exist. These are sometimes called "pelagic" or "oceanic" islands. Others consist of simple volcanic cones rising out of deep water. These are volcanic islands. Lastly, there are some that have been formed altogether by the labours of a small marine animal, called the coral animal, and these are called coral islands.

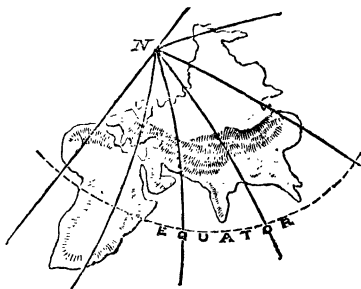
All the islands probably refer either to the existing or former position of continental land. They are of various sizes, some—especially those extending from China towards Australia—being of great magnitude, each containing more than a hundred thousand square miles. For the most part they are much smaller, and collected into groups of many in each group. Some few, however, are detached. A group of islands may be regarded as the summits of land buried under the waves. All the connecting land exists, but is for the present out of sight. If the sea-bottom were raised, or the level of the sea lowered, such islands would become parts of a continent.

Continents may with advantage be considered as including the islands near them, where they are only separated by shallow water. In most cases the vegetation of such islands, and their animal inhabitants, prove how real this view is. Occasionally, no doubt, the case is different, and such cases demand careful attention from the naturalist and geologist, as they are sure to suggest useful reflections.

The form of the great masses of land, and of the larger islands, presents many facts of considerable

interest. Let the student refer to the annexed diagram, or to a globe, and look at the form of the

FIG. 4.—THE OLD WORLD, OR EASTERN CONTINENT.



mass of land called the Old World. It extends from east to west for a vast distance, measured from the western extremity of Spain, where the Pyrenees die away under the Atlantic waves, to the eastern extremity of China, a distance of about nine thousand miles. A line of very high land runs through it in the direction of its greater length, namely, from east to west, including several important chains of mountains rising here and there in long systems of ridges, in other places sending up peaks far above the clouds, capped with snow summer and winter, and forming a barrier separating climates, vegetation, and races of animals and men. On the north of this central line are vast plains, some low or near the sea, some lofty, and serving as the bases of great mountains. Towards the north pole these lands are for the most part cold, and there are large tracts little occupied by men. In these northern lands, however, have originated

the races most active in war, and often overrunning and subduing the world. The northern lands terminate in the Arctic or North Polar Sea by a number of islands, some of considerable size.

The great continent south of the central line of high land, which is sometimes called its geographical axis, divides into a multitude of projecting lands called promontories, all more or less triangular in shape (not much unlike the shape of a leg of mutton), and all pointing towards the south. Only one of these stretches down beyond the equator into the Southern hemisphere, and this is the great mass of Africa. The succession of promontories pointing thus southwards includes Arabia, Hindostan, the Malay peninsula, and Cochin China.

But Europe is separated from Africa by an inland sea, and in this sea also almost all the land ends in promontories looking southward. The Iberian peninsula (including Spain and Portugal), Italy, and Greece are illustrations of this. Even in the northern part of the great continent the same peculiarity is noticeable, and this is well shown in the Scandinavian peninsula (Sweden and Norway) and in Kamtschatka. Some of the large islands and island groups point to a similar construction.

If now we turn our attention to the New World, or American continent, we shall also find marked peculiarities of position. The longest line that can be drawn (its length is nearly 10,000 miles) extends not from east to west, but from north to south. In this direction also it possesses a line of lofty highlands only inferior in their highest elevations to the mountain peaks of Asia, and reaching almost from pole to pole. As in the great continent, this is a

barrier preventing the migration of plants and animals, and greatly affecting climate, but, owing to its direction, it acts in a very different manner from the other. The lands to the east are wide plains nowhere very lofty, and sometimes very low. The western lands are narrow strips bordering the ocean. There are high plains included among the mountains.

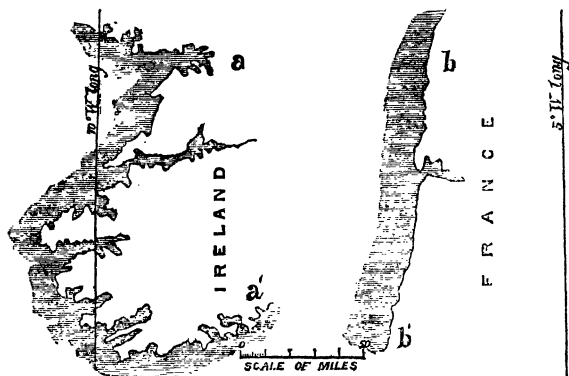
But though there is no resemblance in the position of its geographical axis, the general form of American land, both north and south of the equator, has resemblances to that of the other continent. North America and South America are both triangular in shape, and in both the triangle points southwards. In North America there are many promontories and peninsulas, but all show the same peculiarity. California, on the west, and Florida, on the east, are striking examples. Aliaska is another illustration; Greenland is another. South America is without promontories: it is itself one huge promontory.

Returning now to the Old World, a very slight glance at our little map will serve to satisfy the student of another fact with regard to the form of the land. The coast of certain parts of the world is very much broken and irregular, but in other parts there are long distances without any indentation. The learner may with advantage, in reference to this matter, compare and contrast the coast of Northern Europe, or the shores of the Mediterranean, with the western or northern coast of Africa. It is easy to understand that numerous bays, inlets, and harbours are convenient for shipping, and therefore advantageous for trade. No country that is not so provided can hope to rival in commerce the countries that have good and numerous harbours. An ex-

ample may be seen in the difference between the coast line of England and France. Along the shores of the British Channel there is hardly a single inlet forming a natural harbour, into which vessels could take shelter on the French side, from Cape Finis-terre to Calais. The opposite or English coast has a succession of harbours all more or less good, and some excellent. Falmouth, Plymouth, Dartmouth, and Portsmouth are but a few out of the number. The result is seen in the fact that almost all the trade between England and France is carried on by English ships.

A still more remarkable instance is illustrated in the annexed diagram, where a part of the Atlantic

FIG. 5.—COMPARISON OF COAST-LINES.



a a'.—West coast of Ireland (Galway to Cape Clear), 650 miles.
b b'.—West coast of France (Mouth of the Gironde to Bayonne), 160 miles.
 (Distance in latitude, 140 miles.)

coast of Ireland is compared with part of the Atlantic coast of France. Within the same distance in latitude the former is four times the length of the latter.

It has been suggested, that the greater the number of miles of coast-line (including all the indentations), in proportion to the area of the country, the more accessible is the country, the more given to sea pursuits are its inhabitants, and the more completely do its inhabitants become civilized and free from the limited views and narrow prejudices that are so common among people who rarely leave their own country and home. Africa, as a great continent in the old sense of the word, affords an admirable example of this fact. It has scarcely any means of access by water from the coast to the interior, and hardly any inlets or bays of importance along its whole coast. The condition of its inhabitants remains, in spite of constant communication with the outer world, the most degraded and hopeless to be found in any country. Like many other general rules founded on a limited consideration of facts, there are important exceptions to this rule. Ireland affords a remarkable example.

There are other important facts regarding the distribution of the land. About one-fourth part of the earth's surface rises above the sea-level, but the whole of Europe and Asia, and great part of Africa, lie north of the equator; and it is well known that the whole of North America, and part of South America, are also in the Northern hemisphere. In fact, the land is at present so distributed that almost the whole is contained in one half of the globe, while the other half, except in the case of Australia and New Zealand, is almost entirely under water. If a person were to be placed exactly over the county of Cornwall, in England, at a sufficient height to see half the earth's surface, he would see almost all the land.

Another person placed immediately over New Zealand would see New Zealand, Australia, part of South America, and a vast multitude of small islands in the Pacific, but the total amount of land visible would not amount to much more than a twelfth part of the whole.

There is thus what is called a hemisphere of greatest land, opposed to another in which there is hardly any land rising above the sea-level. Even of that little land here found a part was separated from sea-water,

FIG. 6.—HEMISPHERE OF GREATEST LAND.



and built up atom by atom by the coral animal, which has gradually increased year after year in the warm seas, until it has constructed reefs hundreds of miles in length, some of which are now converted into habitable land.

The fact that of two halves of the world one projects or bulges above the general level, while the other recedes, or is depressed below it, is very curious,

and cannot but have an important meaning. The cause, however, is not clear, and the student need not at present enter into the various speculations that have been made concerning it. There is no doubt whatever that the climate, both of the whole earth and of every country, however situated, is greatly affected by this arrangement of the land, which is by no means essential, and which has, at some periods of the earth's history, been very different

Besides the distribution of the land as we have been considering it—that, namely, which relates to the position of the line where the ocean comes in contact with the land—there is another hardly less important. If we call that which has just been described its horizontal distribution, the other may, in the same sense, be called its vertical distribution. The land is not like the water, kept at a uniform level, its surface being always at the same distance from the centre of the earth. The whole nature of the earth, as a place of habitation, depends on the existence of irregularities. The ocean fills up depressions to a certain point, but the place where the sea comes in contact with the land may be nearly flat, and in this case the difference of a few feet in the level of the water would make a difference of hundreds of yards wide of coast. Or the land may be met on the gentle slope of a hill, and in this case an alteration in the height of the water amounting to many feet is hardly to be recognized. Or, lastly, the shore may be precipitous, not merely having a steep inland cliff—for that is not uncommon where the slope is gentle—but really descending abruptly for a great depth close to the shore. These three

conditions may be continued either outwards, on the sea-bottom, or inland, towards the mountain chain or geographical axis of the country.

The vertical distribution of land causes a division of the whole of the exposed surface into three or four tolerably well marked forms. The flat lands, sometimes extending from the sea for a very great distance, and sometimes near the foot of a mountain range in the far interior, rise very gently, and are only occasionally broken by low hills. They are known by various names in different countries, according to local conditions of latitude, climate, and soil, to which they are exposed. In Russia they are *steppes*; in Arabia and the interior of Africa, *deserts*; in North America they are *prairies* and *savannahs*; in South America, *llanos*, *silvas*, and *pampas*. In every case there are peculiarities belonging to the country and climate, but all agree in being "low plains." In some parts of the world the land continues to rise gradually from the coast, till the elevation above the sea becomes considerable; more frequently it rises in steps by a succession of low cliffs; but here and there the sea terminates abruptly, and mountains or lofty plains rise at once from considerable depths of water. The diagram, Fig. 7, p. 33, will illustrate this fact. It represents, in a very general way, the outline, or *contour* (as it is called in geography) of Central and Northern Asia from India to the shores of the Arctic Ocean.

Lofty plains (also called "table-lands" and "plateaux") often differ little from low plains in general appearance. They commence rarely from the coast, but often rise from plains by steep and lofty cliffs or hillsides, almost resembling mountain ranges. They are

sometimes included among, and form part of mountain chains, and they occasionally form the central masses of great continents. What is most remarkable about such plains is the nature of the valleys with which they are intersected. These are deep cuts or gorges, sometimes wide, but always abrupt.

Mountains are natural phenomena of the grandest kind. They rise abruptly from the sea or from plains, whether low or lofty, and their sides are jagged and abrupt. They form ridges of hard rock, terminating upwards in a succession of peaks, whose form depends on the nature of the rock. They exhibit beyond all comparison the most picturesque and grandest, though often the most gloomy and terrible, conditions of the land. They appear generally in groups, but these groups are connected together, and from each may proceed spurs or secondary mountains at right angles to the main chain, which is formed by a number of groups in the same general direction. Of mountain chains of the first class there are but two—those, namely, that traverse the two great masses of land in the Eastern and Western hemispheres. Of mountain chains of the second class, and of small groups, the number is very great, some being found in almost every important mass of land.

Valleys are either grooves or furrows on mountain sides, or fissures and ravines cutting deeply into table-lands. They are everywhere the natural channels conducting back to its parent ocean the water that has fallen from the sky as rain. Their origin is rarely doubtful. They have been eaten out by the water that has passed through them.

According to their mode of formation, and the nature of the country they cut through, they offer

the wildest, the grandest, or the most beautiful and softest scenery. It is not always that rivers run through them, but they have been formed by rivers, and are ready to act as water conduits when required.

Such are the varieties of form of the land. Besides these well-marked differences, each country has its own special character and its own features by which it can be recognized and identified. All these features may be traced without much difficulty to a common origin, and are explained by a reference to the changes now being produced on the surface. But this explanation would lead to another branch of the subject, which it is not at present advisable to discuss. It is enough for the student to know and feel that there is an orderly and regulated system traceable throughout, and that the laws of nature in the formation of the irregularities of the earth's surface are perfectly clear and well defined, certain causes always producing certain effects, and the general result, as now observed, being due to a succession of changes constantly going on upon and within the earth. The nature and amount of these changes it is a part of the science of Physical geography to determine.

CHAPTER III.

MOUNTAINS AND ELEVATED PLAINS—LOW PLAINS AND
VALLEYS.Fig. 7.—CONTOUR SECTION : VALLEY OF THE GANGES TO THE ARCTIC
OCEAN.*a.*—Himalaya mountains. *b.*—Plateaux and mountains of Central Asia. *c.*—Low plains of Siberia (Steppes and Tundra).

THE student will observe, on looking at the map forming the frontispiece of this volume, a dark line crossing the two great tracts of land, and in each case in the direction of their greatest length. This line represents the ridge of highest land, which generally consists of rugged and jagged ridges and detached peaks, rising from lofty plains, often cut through by deep chasms. The groups are connected by narrow necks of rock, over which a passage can be made with more or less difficulty. Each group forms a mountain or a mountain mass. Several such groups together form a mountain chain, and a number of these chains continued in the same direction become a mountain system. In Switzerland and some parts of France and Germany there are elevations of this kind well known to all travellers. The mountain called Mont Blanc rises nearly 16,000 feet above the sea. It is sufficiently detached to be recognized as

a single mountain, but it is connected with other mountains on the east and west by a number of narrow necks called passes. These mountains, again, are connected with others, all of which are spoken of under one name, as the group of the Savoy Alps. A little to the north are the Oberland Alps, including several well-known mountains rising to a great height. All these unite to form the mountain chain of the Western Alps. To the south are the Maritime Alps; to the east and in the Tyrol, but connected with these, are the Eastern Alps. The Carnic and the Noric Alps and the Julian Alps are names of various portions. Thus the mountain system of the Alps reaches across Europe from the plains of Languedoc to near Hungary.

Immediately to the south and west of the plains of Languedoc, and quite detached from the Alps, though at no great distance, another mountain chain commences, well known as the Pyrenees.

Immediately to the east of the Alps, in Hungary, we have, in a similar way, another chain, that of the Carpathians. From the Carpathians it is not difficult to trace a succession of mountain chains and systems into Asia, where the Caucasus, the Hindu Koosh, and the Himalayan chain, present lofty peaks, some of them the loftiest that rise above the general surface of our globe. They are as much as six miles above the sea. Beyond the Himalayas the mountain system is continued by the Altai mountains and the mountains of China to the Pacific.

But besides the chains of the Alps and other mountains which cross Central Europe, there is another system of mountains rising out of the general geographical axis of the Old World, known

as the Atlas chain. These form the northern extremity of Africa. When the whole of the land of the Old World is regarded as one, it is found that the Alpine and the Atlas mountains can only be looked on as the north and south ridges of a vast tract, much of which is elevated, but which has large and deep depressions between the principal elevations. Of these depressions the bed of the Mediterranean Sea is one of the most extensive, and it separates Europe from Africa. It is connected with other still deeper depressions, extending into Asia. But at the two extremities of this depression the mountain chains are connected by very lofty plains, and even by distinct mountain chains. Thus the student will see that the geographical axis marked in our map includes a very broad tract of mountains and plains; that it is not merely a single continued ridge, but a very complex system, and that it must be carefully studied before its true nature is understood.

Mountains, mountain chains, and mountain systems are of great interest to the Physical geographer; for they serve as the clue by which he makes out the true history of the world. They are regarded, with reason, as a kind of skeleton framework, and thus all that can be made out concerning them is worth knowing. Almost all the great chains are connected with others of lower altitude, which cross their direction almost at right angles. These secondary chains, called spurs, often form the hard central part or backbone of those long peninsulas and promontories that have been mentioned as particularly common on the south side of the central axis of the Old World. Thus the Apennines run out from the Alps to form Italy. The Pindus chain, in the same

way, runs out to form Greece. There is a similar chain of high lands marking the outline of many other of the chief promontories. The Balkan is an eastern continuation of the Dinaric branch of the Alps, at the point where the Pindus branches.

The two great parallel chains of the Atlas to the south, and the Pyrenees and Alps to the north, are not everywhere disconnected. Between them, on the west, are no less than three subordinate and parallel chains in Spain, of which the Sierra Nevada, the loftiest, rises to the altitude of nearly 12,000 feet. On the east they are connected by the mountains of Palestine, the Taurus, and the Antitaurus, of which Ararat (16,000 feet) is one of the loftiest peaks. Not far off are the mountains of the Caucasus, rising to nearly 18,000 feet. This double link enables us easily to recognize the fact of the identity of the two series of mountain chains as parts of one vast system.

Including the double chain, the whole breadth of the great geographical axis of the Old World is not less than 1,000 miles. The length we have already stated to approach 9,000 miles. The height varies. In the eastern Pyrenees, which is of the nature of a jagged ridge, the highest peak is Mount Maledetta (more than 11,000 feet). The western Pyrenees, on the north coast of Spain, where the system and chain die away into the Atlantic, are much lower.

The Alps are a lofty group. There are at least a hundred peaks of more than 10,000 feet, several more than 12,000 feet, and some more than 16,000 feet. The Carpathians are less lofty, but rise to nearly 10,000 feet in one point. The Balkan con-

nect with the Carpathians, and also approach 10,000 feet. The highest mountain of the Apennines is 9,500 feet, and of Greece about 8,000. These are in transverse chains.

The Atlas chain, parallel to all these, rises to nearly 12,000 feet, and dies away towards Egypt, though stretching westwards far beyond the coast of Africa, as marked by the Western Islands, which are isolated lofty peaks rising above the level of the Atlantic. The eastern Atlas connects with the mountains of Arabia and Asia Minor; and in Western Asia the two western branches of the mountain system of the Old World converge. The Hindu Koosh follows, and is succeeded by the Himalaya chain, the loftiest on the globe. To the north of this chain are lofty plains and mountain ranges, contrasting strangely with the depressions of the Mediterranean Sea and the Aralo-Caspian Sea. The higher peaks of the Hindu Koosh exceed 20,000 feet, and of the Himalaya there are many that exceed 28,000 feet.

In the several divisions of the mountain system of the Old World there are many peculiarities of great interest connected with the elevations. The slopes of all mountain chains are gradual on one side and steeper on the other. In the Alps the slope of the mountain sides is gradual on the northern and steeper on the southern side. The difference is great, strongly marked, and uniform. But the average slope of a mountain, measured by the angle enclosed between a horizontal line and a line drawn from the nearest low plains to the summit, or from the nearest sea-level to the summit, is generally very small, and when smallest does not at all prevent a very rugged and inaccessible mountain side from being presented

to the adventurous traveller. An average ascent of one in thirty, or 180 feet in a mile—a slope that can be ascended by an ordinary train on a railway—would be equivalent to the slope if the total ascent to the summit of Mont Blanc were 100 miles from the nearest low land at the sea-level. It is consistent with the existence of flanking ranges separated by deep valleys and a succession of steep slopes, some of which a goat could hardly scale, rendering the ascent a feat rarely attempted, and never executed without serious risk. The ascent is more difficult and steeper on the south than on the north side.

Throughout the mountain chains on the northern side of the geographical axis of the Old World this continues to be the case. The cause depends on geological considerations.

The mountain chain of the Himalaya is connected with a series of very lofty tracts, out of which mountains arise, but which are as level as the low plains near the sea. These are the lofty plains of Central and Northern Asia. It would seem unnecessary to point out the fact that flat lands are not necessarily low lands; but most people associate an idea of lowness or nearness to the sea-level with any extensive plain. In nature, high plains are very common, and they exist within or on one side of almost all mountain chains. In Europe they occur in the Iberian peninsula (Spain and Portugal), where a lofty flat country on the south contrasts strongly with the low flat country of Languedoc, on the north of the chain of the Pyrenees.

The Pyrenean chain rises very suddenly and to a great height on the French side, like a wall. On the opposite, or Spanish side, the descent is very

much less, and reaches only to the plains of Castile, between 2,000 and 3,000 feet above the sea. Through deep cuts or gorges in these plains the rivers have eaten their way, and throughout Spain to the southern coast the same general character is retained. Out of these plains rise three principal mountain ranges, of small breadth; one of them is the Sierra Nevada, only inferior in elevation to the loftiest of the Alpine groups.

Much of the same kind, but on a still grander scale, is the table-land of Abyssinia, difficult of access from the sea, owing to the rocky and precipitous nature of the mountain gorges, and equally difficult to cross, because of the deep ravines, in which run the tributaries of the Nile, that make their way through them. The plateaux of Arabia and Persia are similar, though of inferior elevation. The high plains of Armenia succeed them. Next comes the vast plateau or table-land of Tibet, from 6,000 to 10,000 feet above the sea, broken up into many divisions, but including the most extensive tracts of high land on the globe. It extends from the northern foot of the Himalaya to the foot of the mountains of Eastern China. South of the Himalaya are the plains and mountains of Northern India, which are continued towards the south in the Western and Eastern Ghâts and the Neilgherey Hills.

Besides Abyssinia, almost the whole of the coast lands of Africa, from the equator to the Cape of Good Hope, on both sides of the continent, consist of table-lands rising somewhat rapidly from the sea to a considerable height, retaining that height, with few undulations, for a breadth of some hundred miles,

and then subsiding gradually towards the interior. The southern streams of the continent pass out to the sea by narrow channels, but, except the Zambesi, whose course was followed by Dr. Livingstone, there is hardly any river of importance. Thus Africa has a belt of table-land near the coast from 3,000 to 6,000 feet above the sea, while in Europe and Asia the table-lands are in the interior, and are directly connected with the mountain system of the Old World. Out of the African table-land rise mountains, one of which exceeds 20,000 feet.

The Western continent also possesses its geographical axis. It is, however, a north and south axis, instead of an east and west. No wonder that, with so great and important a difference, the conditions of life in the New World differ so greatly from those of the Old World. Of the two parts of the American land the northern is much the wider, and much the more complicated in its structure, and it is that which compares most easily with the Old World. The chief mountains of North America are the Rocky Mountains, some of which are volcanic, ranging nearly from the Arctic circle to the Mexican table-land. They are lofty and grand, but are not alone. They are flanked towards the Pacific coast by other chains of smaller elevation, and between them are important valleys, lakes, and deserts, but no very high plains. Towards the interior of the continent there are other, though less considerable, mountains. But the chief point of importance is the existence of a second range near the east coast, called the Alleghany Mountains, much less lofty, but parallel with the main range, although separated from it by a great breadth of prairie land, watered by the Missouri and Mis-

issippi. The Alleghany Mountains are continued, though not by mountains of great elevation, and with occasional intervals, both north-eastwards, into Canada, and southwards, to the northern group of the West Indian islands. Perhaps the group of the Antilles to the south-east indicate a connecting link with the eastern mountain chains of South America.

The great mountain system of America, commencing with the Rocky Mountains, is continued southwards by the mountains and table-land of Mexico, and thence, by a perfectly continuous chain, to the Andes of New Granada. Once entered on the chain or *cordillera** of the Andes, we find a very well-marked series of groups, all of the same general nature, consisting of very lofty but small plateaux or table-lands, situated amongst a number of conical and jagged peaks, often volcanic, and many of them only inferior in altitude to the highest parts of the Himalayan chain. These groups are separated, but the passes over the necks between them are of great height, and most of them very difficult of access. Several, however, are now regularly travelled. The chains of the Andes south of New Granada are those of Quito, Peru, Bolivia, Chili, and Patagonia. Still farther south the chain is represented by detached summits seen above the level of the sea (the Tierra del Fuego), until at length these connect with the highlands of the Antarctic circle.

South America, like North America, has a second mountain system, though it is even less completely developed. It is recognized in the Brazilian mountains already alluded to, and these are important as

* The Spanish name for a mountain chain of importance.

dividing waters of considerable magnitude. The Organ Mountains of Brazil are not lofty, but they are beyond measure rich in vegetable life.

The different members of the great system of the Andes all contain plains, though for the most part they are of small size. Some are nearly as high as the summits of the highest mountains of Europe. Some have lakes of fresh water, and the shores of some of these lakes are inhabited. A few are of sufficient size to be objects of very great interest. There are scarcely any elevated plains of large size on the American continent, except that on which the city of Mexico is built.

Australia has one mountain system. It is not very lofty, but has all the properties of a system. Its range is nearly north-south, and it agrees in this respect rather with the subordinate mountain groups representing spurs of the great system, than with any part of the general system itself. The position of Australia connects it distinctly with the Old World rather than with the New; but there are appearances of a sunken continent in part of the Pacific Ocean with which they may still better agree. The Australian Alps run along from north to south on the eastern side of that continent, and appear to connect by submarine elevations with the islands of New Zealand, which have a lofty and volcanic chain running through them. There are no elevated plains among these mountains, nor are they double or compound groups.

Besides the great mountain systems, the parallel or flanking chains of lower elevation are subordinate to them; and included with them and the spurs, or projecting ranges, also subordinate, there exist in certain parts of the world isolated mountains, gene-

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rally volcanic, and isolated or detached groups, quite independent of any main system. Among the latter is the Scandinavian chain, which has no dependence on the Alps, and does not approach the Pyrenees, and which can in no sense be regarded as a spur of any part of the great mountain system of the Old World. The Scandinavian chain, though not lofty, is in all respects a true mountain group. It connects southwards with the Scottish mountains and those of Cumberland and Wales, and perhaps Ireland, but cannot be traced farther. It appears, indeed, to be of very much greater antiquity than the main system, and indicates perhaps the position of a geographical axis at a very early period of the earth's history. The Ural chain, also very low, has the same direction, and does not seem to be a spur of the Caucasus.

In the great islands of the earth there is generally a central mountain axis, often of very great elevation at some few points. In many cases such high peaks are the cones of volcanoes; but in others, and indeed in most cases, the mountain chain will be found subordinate to that of the nearest adjacent continent. This is the case in Madagascar. It is also the case in the great islands of the Indian Archipelago.

Although it is not easy to draw any very decided line between hills and mountains, the words being used in common language rather to distinguish cases of relative height above the sea than describe structure, it is still convenient to recognize a distinction. Thus, in Wales and Scotland the elevated summits, though not loftier than hills, are really mountains. For the same reason the Malvern Hills are structurally mountains, for all are parts of a

great old mountain system. They are not of any great elevation, but their scenery is peculiar, and their outline simple and bold. Many elevations far more considerable have no pretension whatever to the mountain character. The real difference lies rather in the geology than the geography of the district; but, under any circumstances, mountains belong to great geological movements, generally of upheaval, which have displaced and tilted all the rocks, and hills are examples of recent denudation. In the case of mountains the original displacement has been followed by the wearing away of the loose broken and soft rocks, leaving bare the lower and harder kinds. Thus mountains involve elevation, followed no doubt by the process called *aqueous denudation*, or the clearing away by water of the broken and soft material. Hills, on the contrary, when properly so named, are the irregularities and uneven surfaces of soft and modern rocks, as cleared by the action of weather, and especially rain and frost. This is called *aërial denudation*. The irregularities of surface in table-lands are rarely more than are due to the partial removal of the rock, whatever it be, of which the table-land is composed. In time, table-lands of small elevation and moderate extent become converted into hilly districts, simply by the gradual widening and intersection of the valleys produced by aërial denudation.

Valleys are furrows or depressions either on the sides of mountains or in table-lands; but the low ground, nearly level, through which a river runs, after having left the mountains and high ground, and before it reaches the sea, continues to be called valley, although no longer a depression. Thus the Rhine,

commencing with the melted snow of the Alpine glaciers, runs for a long distance in a distinct valley between rocks and cliffs, or between bold hills on either side, and opens out at length in the broad flat expanse of Holland. This wide tract of flat land is also regarded as part of the valley of the Rhine, till we reach the point where the mud already deposited by the stream where it meets the sea is the only land that remains. The same is the case with other great rivers terminating in a wide level plain.

Looked on in this light, valleys are of several kinds. Some are mere mountain gorges or ravines, very steeply inclined, having rocky sides, and serving as conduits to carry off the water that comes down in torrents from high lands after heavy rain. Such valleys, in their upper part, may receive the snows that there replace rain, and these snows, freezing and constantly increasing in quantity, may become enormous masses of ice, or *glaciers* (see p. 98), which reach the lower and warmer parts of the valleys faster than they can be melted. In such cases they encroach on the lands that might otherwise be cultivated. Generally, however, the valleys of mountain districts are water-channels, carrying down the rains into the comparatively level lands below. At first the streams are mountain torrents, but as they descend towards the open country they gradually open out and lose something of their torrential character. But it rarely happens that they fail in indicating their origin. They are due partly to the variations and irregularities of surface inevitable when rocks have been lifted up many thousand feet and converted into mountains, but chiefly to the perpetual action of water flowing over and amongst them,

undermining some rocks and eating out others, but always tending to widen and deepen the water-course, and generally selecting the readiest course downwards.

But all valleys are not of this kind. There are some which do not commence on the sides of high mountains, which have no glaciers, and which have nothing to do with torrents. Such are the valleys of table-lands. They are clefts or ravines in flat limestone or other rocks, often winding about in a complicated manner, often conveying vast bodies of water, which may rush along and fall over precipices, or run rapidly over huge stones, but usually having highly inclined or vertical walls, which close them in distinctly and strictly, though sometimes they are miles apart.

Few varieties of scenery are more grand than those which are offered in valleys of this kind. They often commence abruptly in a narrow fissure in the rock. Becoming watercourses, which must happen when they receive the drainage of the elevated plain they intersect, they naturally become worn and show the action of water; but in many cases they retain their essential characteristics as long and comparatively narrow clefts in rocks, lying almost horizontally, and whose surface is many hundred, perhaps many thousand feet above the sea.

Deep narrow valleys in table-lands, and mountain valleys generally, terminate abruptly before they reach the sea; and during the rest of their course the rivers that have been carried through them continue their course to the sea through flat lands, very little elevated.

Such flat lands are called low plains. They are in

most countries very extensive, and in some compose by far the largest part of their surface. Like the table-lands, they are known by different names in different countries, but the same general description applies to all. Besides the low plains crossed by rivers, there are, however, some others in the interior of continents that are in no way connected with drainage. Some of these are barren, as the great deserts of Africa and Arabia. Some are more fertile.

Almost all the principal divisions of the earth contain large tracts of low plain. In the south-east of Europe there is a vast expanse of level land, about sixty feet above the level of the Black Sea, known as the *steppes*. These vast plains reach back in places to the Arctic Ocean, without interruption from rising ground, except a very few low hills. They are to some extent undulating, but only because here and there depressions appear, in which during winter the snow rests, although in summer there are villages in them. They contain a few trees, and generally water may be found by digging. With the exception of these hollows, only seen when nearly reached, there is no break in the monotony of the landscape. In summer the plains are partially cultivated, and good crops are got from them. They are extensive enough to grow corn for the whole of Europe. There are no roads over them, and no stones. The value of the soil varies greatly in different parts, but the characteristics of the surface remain. These vast plains extend into Siberia, and across the whole of Northern Asia.

In Arabia and in the interior of North Africa are extensive low plains, called *deserts*, in which little rain falls, and where no cultivation is possible, except

in the comparatively few parts where springs of water either exist naturally or have been reached by sinking wells. In the central parts of Africa, below the equator, there is also a large area of low flat lands.

North America has very extensive tracts, known as *prairies* or *savannahs*. They occupy more than two-and-a-half millions of square miles, chiefly between the Rocky Mountains and the Alleghanies. There are several varieties, some being plains covered with low bushes and heath, others are grassy, others again covered with pools and swamps; while some extensive districts are covered with loose sand, which, till properly checked and kept from shifting, is constantly tending to extend its sway, and convert good cultivable lands into deserts. The pine is an invaluable remedy in such cases, and the great tracts partly covered with pine are called pine-barrens. Other wide tracts of low land, more to the north, are swamps in rainy weather, and only available during the fine season. On both the great continents there is a vast preponderance of low plains towards the northern extremity.

In South America we have first, in the northern part, the *llanos*, or low plains, traversed by the Orinoco and Amazon. These are of two kinds: one consists of forest plains, of which there is more than a million of square miles, much of which is inundated every year; and this part is covered with rich tree vegetation or forest coming down to the water's edge, and is little above the level of the rivers. The other kind (called *llanos altos*) occur in the upper part of the river, are much smaller, and are comparatively barren. They are without stones, and covered chiefly with grass.

The *pampas* are also treeless plains, and are nearly as extensive as the llanos, occupying a length of nearly 2,000 miles. They stretch across a large portion of the south temperate zone in South America, reaching into Patagonia; and, though varying in different places, are for the most part level, or very slightly undulating plains, without trees, and yielding an almost indefinite supply of herbage for horses and cattle.

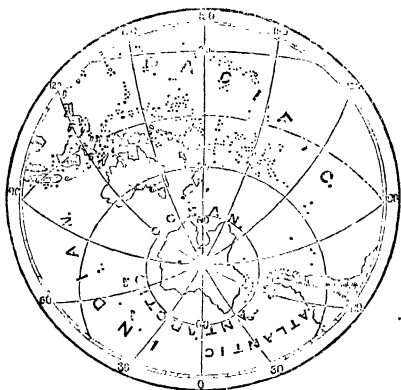
Australia has extensive low plains in the interior as well as on the coast, and they are covered with vegetation at one period of the year, but dry and naked at other times.

Other large islands on the earth are similarly provided. It is easy to perceive that the low plains and valleys are more important in many ways—in the area they occupy, in their usefulness to man, the nature of their products, and the relation they bear to the rest of the land—than mountains and plateaux. They have also, and always have had, a marked reference to the distribution of plants, animals, and human races. It is the mountain chains that mark the grand outlines, and represent the bony framework of the earth, but the lower lands are those on which plants and animals best thrive.

CHAPTER IV.

THE OCEAN.

FIG. 8.—HEMISPHERE OF GREATEST WATER.



THREE-FOURTHS of the whole surface of the earth being covered by water, which occupies almost every depression below a certain level, and whose surface remains at the same distance from the earth's centre, it will be understood that the form and position of the coast-line which rises above that surface absolutely determines the form and number of the different sheets of water. Strictly speaking, however, there is only one ocean or expanse of water; for the great continent, or Old World, the continent of America, and that of Australia, are but the largest of

a multitude of detached lands surrounded with water. For the sake of convenience it is usual to recognize several divisions of this great body, although in this case, as in the designation of the land, geographers have not always been agreed as to the method of dividing and the names to be given.

Three great oceans are very easily determined. One is very much larger than either of the others, but all are well defined. The largest is the Pacific, the Atlantic comes next, and the Indian Ocean is the smallest. The water contained between the western coasts of Europe and Africa and the eastern coast of the two Americas is that usually called the Atlantic Ocean, sometimes the Atlantic Canal, from its narrowness in proportion to its length. It is the ocean of chief interest to civilized nations. The Pacific, though far larger, is less important. It extends from the east coast of the land and islands of the Old World and Australia to the west coast of the New World : it covers more than half the surface of the globe. These two great oceans are open to and connected with others of much smaller size. Between the Pacific and the coast of Africa is the third, or Indian Ocean. Between the Atlantic and Pacific, towards the north, is the Arctic Ocean ; and between the Atlantic, Pacific, and Indian Oceans, and the South Polar land, is the Antarctic Ocean. These two (sometimes called the Polar Seas) afford a ready communication by the south, and a much more difficult but open-water communication by the north between the Atlantic and Pacific Oceans.

The Atlantic Ocean, though very much smaller than the Pacific, is better known, because it is much more frequented, and is the great highway of trade

between the most commercial and energetic peoples in the world. It is bounded by the western shores of Europe, and two vast seas, the Mediterranean and the Baltic, open into it from the east. The former runs far inland between the south of Europe and the north of Africa, washing the shores of Asia Minor, and penetrates by the Black Sea into Asia. The Baltic is a very extensive but shallow sea, entering the north of Europe. On the other side the Atlantic washes the eastern shores of North America; and there also great inland seas, opening into it, penetrate the land to a vast distance. Between North and South America the Gulf of Mexico and the Caribbean Sea partake of the nature of inland seas, and add greatly to the magnitude of the Atlantic; and the length of its coast-line is everywhere exceedingly great compared with its area. The length of the Atlantic from the Arctic to the Antarctic Oceans is about 9,000 miles. Its breadth is irregular, varying from 800 miles between Greenland and Norway to more than 5,000 miles under the tropic of Cancer. It diminishes in breadth towards the south, and between Africa and Brazil is only about 1,500 miles. It again widens still further south, as the shores of Africa and South America diverge gradually; and between the Cape of Good Hope and South America the distance is nearly 4,000 miles. The area of the ocean is about 27,000,000 of square miles.

The Atlantic Ocean is thus a great canal, ranging north and south, and allowing of a direct water communication from the Arctic to the Antarctic Seas. Crossing the equator, and reaching nearly to the two poles, its waters exhibit every variety of tempe-

rature, being heated at the equator to as much as 90 degrees, and lowered to the freezing point towards the poles. The varieties of motion to which it is subject are not less extreme than those of temperature; and in all we may recognize the influence of the vast tracts of land which enclose it and force it into various conditions, which again react on the land, especially on the shores of the two continents, and most especially on the lands in the Northern hemisphere, where the influence is on all accounts the greatest.

Hence it is that the Atlantic is frequently disturbed by storms, and is dangerous from the magnitude and broken nature of its principal waves; hence, also, the complication it offers of those periodical movements called tides; also the more regular movements or currents, which are strongly marked chiefly because of the canal form of this ocean. The atmosphere over it is also greatly affected by the form of the enclosing land, the tides, and the currents, and all these acting in concert greatly affect the climate of lands far away from the immediate shores of the ocean. It would need long and careful study to determine all the results of the form, extent, and direction of the Atlantic Ocean.

The form and depth of the bottom of this great body of water are also important, and have great influence on the movements of its waters. It is not easy to learn accurately the form of an ocean floor. We cannot hope to see it under any circumstances. We can only reach the deeper parts by very carefully contrived apparatus; and while each separate observation taken in deep water requires much time as well as numerous precautions to prevent

it needs many thousand such observations to give even a faint outline of the truth. This work has, however, been done to some extent; and not only the form but the actual material of the floor of the Atlantic are known. Deprived of its water, the bed of this ocean would be a deep valley, with some very deep depressions. Like other large depressed tracts of land between two mountain chains, it would present large level areas but little depressed, occasional hills varying the surface of these low plains, sudden and rapid slopes descending to lower levels; these representing, but in inverted order, the high plains or plateaux of the land, and other depressions reaching profound depths representing mountain chains and lofty peaks. The depths nearly correspond with the heights on land. The greatest depth in the Atlantic is something greater than the greatest height of the Himalayan chain.

There are islands in the Atlantic, consisting of detached peaks rising out of deep water, and many more and larger islands near continents, consisting of irregular summits, separated by small depths of water from the nearest land. But the islands are few and unimportant compared with the magnitude of the ocean. The West Indian group, the British Isles, the Azores, Madeira, the Canaries, and a few others, are exceptions to a very general rule. There are, however, numerous islands in the Mediterranean and other enclosed seas, although on the whole the Atlantic presents a nearly uninterrupted water surface.

In proportion as the open water is uninterrupted, the line enclosing the waters of this ocean is broken, indented, and elongated. The coast-line of the whole, measured round each bay and headland, and following

each indentation and inland sea, is marvellously extended as compared with what would be the case if there were no breaks. The Atlantic is a sea remarkable for its inland seas and gulfs. The former are of the greatest importance to mankind. The Mediterranean is itself almost an ocean, not so much for its magnitude (which is, however, more than a million and a quarter square miles) as for its varied features and its deep ramifications into the great continent of the Old World. By the canal recently completed through the narrow and low Isthmus of Suez it connects the Atlantic with the Indian Ocean. It separates Europe from Africa. It has many promontories, many gulfs and bays, and several islands; it receives the waters of many large rivers, and is connected with large inland seas, of which the Black Sea and the Sea of Azof are the most important. Many parts are exceedingly deep, and it is divided into two parts by a ridge which at one time formed a connecting link between the Pyrenees and the extremity of the Atlas Mountains. Its waters are salt, and their temperature higher than that of the ocean outside the Straits of Gibraltar, which connect it with the Atlantic. The Baltic is a long, narrow, winding, and shallow sea, having an area of nearly a quarter of a million of square miles. It spreads out like the fingers of a hand. On the shores of the New World we have the Gulf of Mexico, with the Caribbean Sea, and Hudson's and Baffin's Bays, all equally remarkable for a complicated outline, while the Gulf of St. Lawrence, nearly shut in by the peninsulas of Nova Scotia and Newfoundland, completes the outline. Thus the deeply indented coast is a general characteristic.

The Pacific Ocean has an area of nearly 90 millions

of square miles,* and is exceedingly rich in islands. The largest of these are chiefly clustered in the Indian Archipelago and near Australia; but the number of small islands dispersed in the open ocean has never been accurately ascertained. There are certainly many thousands. The form of the Pacific is an oval, wide to the south and narrowing towards the north, leaving only a narrow passage into the Arctic Ocean by Behring's Straits. Owing to its vast size and freedom from interrupting land, this ocean is less subject to violent gales than the Atlantic (whence its name), and its currents are less strongly marked.

On the whole the shores of the Pacific enclose a vast area of water of variable but great depth, and the form of the ocean floor is presumed to resemble that of the Atlantic. This is, however, very imperfectly known, owing to the comparatively small number of observations of depths that have been made, and the far less amount of navigation on its waters.

There are not less than five land-locked or closed seas on the northern shores of the Pacific; but though large they are less important than those of the Atlantic, and very much smaller in proportion to the extent of open water. The peninsula of Alaska and the Aleutian islands enclose the Sea of Behring; the peninsula of Kamtschatka and the Kurile islands shut in the Sea of Okhotsk; the islands of Formosa and Loo Choo enclose the northern China Sea; and the Philippines and Borneo the southern Sea of China. On the American side we have the Gulf of California.

* The area of the Pacific is variously estimated by different geographers, according to the boundaries assumed. The above agrees with the measurements given of the other oceans.

The coast-line of the Pacific is very little indented. On the Asiatic side, although there are several inland seas, they are chiefly formed by islands, and the coast itself is comparatively unbroken, with the exception of a few not very large peninsulas. On the American side California is the only large peninsula, except Alaska. Between California and Patagonia, on a length of coast amounting to about 5,000 miles, there is hardly a promontory or a bay worthy of notice.

The Indian Ocean (area about 23 millions of square miles), unlike the Atlantic and Pacific, is entirely shut off towards the north by the land of Asia. It is enclosed on the west by Africa, on the east by the Malayan peninsula, the islands of Sumatra, Java, &c., and Australia, and is quite open to the south. Its form is that of an irregular triangle. It has many important inland seas, of which that sometimes called the Persian Sea (into which enter the Red Sea and the Persian Gulf) and the Bay of Bengal are the principal, and a few islands, of which Madagascar and Ceylon are by far the largest. Both are connected with the adjacent main land. There are also a multitude of small coral and a few volcanic islands. The length of its coast-line is considerable.

The Arctic Ocean (between three and four millions of square miles) is bounded by the northern coasts of Europe, Asia, and America, and connects both with the Atlantic and Pacific. For a large part of the year it is choked with ice, and from the lands that enclose it huge masses of ice are detached, and float down through this sea into warmer latitudes; but there is some reason to believe that open water extends in summer quite to the Pole. It has a very indented

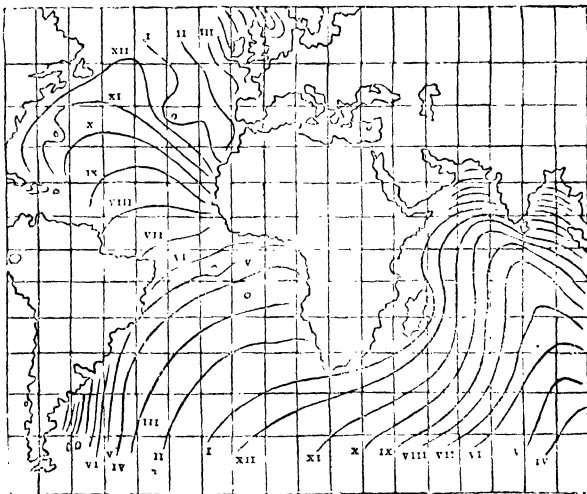
coast-line, and contains some large islands. Greenland is the largest; Nova Zembla, Iceland, and Spitzbergen are all important. The Antarctic Ocean (area 2 millions square miles) is less known than the Arctic. It contains much more land, and is nearly unapproachable, owing to the severity of the cold.

The waters of the ocean are everywhere salt, but the degree of saltiness varies: nearly thirty-five parts in a thousand of solid matter is the average. The salts include about twenty-four parts of common salt, and about four parts each of salts of magnesia and soda, which render the water bitter and nauseous. The other contents are very numerous, but small in quantity. Sea water contains a certain quantity of air, which is necessary to the existence of life. Containing so much solid matter, sea water is denser and weighs heavier than an equal quantity of fresh water. The presence of the salt in water prevents it from freezing at the ordinary temperature at which other water becomes solid.

Owing to the facility with which fluids are moved, the waters of the ocean are constantly exposed to the action of wind and changes of temperature, and are rarely still long together. Besides the winds there is an important cause of disturbance in the direct attraction of the moon, whose position with regard to the earth is constantly shifting, and which, owing to the revolution of the earth on its axis, acts continually at a different part of the surface. The attraction of the moon on the solid earth is in proportion to its mass, but as the whole earth must be drawn together, and only the water that is nearest, the result is not very different in amount; but its effect necessarily is to draw the earth away from the

water on the opposite side. Thus while the water nearest the moon is drawn towards it and bulges a little, the earth being drawn at the same time in the same direction, there is a bulge of water on the opposite side. This is of course constantly going on; and thus, if there were no projecting land, there would be one small wave forming high water at the part of the earth nearest the moon, always following the moon, and another such wave exactly opposite, in the other hemisphere, advancing in the same direction.

FIG. 9.—COURSE OF THE TIDAL WAVE.



(The figures represent hours.)

These two small waves, whose height would probably not exceed a few inches, are in fact formed and travel across the open part of the Pacific Ocean;

but they would hardly be discoverable by the nicest observation, although they originate the true tidal wave. They are greatest when the earth is between the sun and moon, or the moon between the sun and earth, because the sun also acts in the same way, though to a very much smaller extent. Thus the full and new moon are times of high, or, as they are called, spring tides. The influence of the sun and moon at the quarters being opposite, those are times of reduced or neap tides.

The tidal wave being thus formed, it is modified and sent out of its course whenever the land comes in its way. Originating, as we have assumed, in the Pacific, the wave follows the apparent path of the moon from east to west, until it is met by the long chain of islands and lands extending as a barrier for nearly 8,000 miles.

Checked and broken by this barrier, the wave still continues to advance, though it loses its regular character. The amount of rise of the water that cannot be discovered in the open ocean becomes multiplied when forced to pass through narrow channels, and, mixing with the rest of the true tide-wave of each sea, is conducted through the Indian Ocean and round the Cape of Good Hope to the Atlantic. Its progress, however, is then very different. Owing to many interruptions, the wave has been delayed, and several waves are combined; while, owing to the form of the Atlantic valley, the combined wave is altered entirely in direction, and is pushed forward in a direction nearly north. The water being throughout of variable depth, there is a still further cause of modification, and thus we at last obtain that exceedingly complicated alternation of water level

called the Atlantic tidal wave. This wave, whose course and rate of advance are known, and which is already quite distinct from the simple wave described, advances and enters many narrow seas, and thus becomes altered still more, and still further magnified; so that, from being originally measured by inches, it is found to rise and fall twenty, forty, or even seventy feet in certain places. There is another very important consideration. The tidal wave, originally only a moving up and down of the water, involving no forward motion of the body of water in the ocean, becomes at last changed into a positive advance and recession, carrying the water forwards and backwards, and becoming what is called a stream or current. The true tide-wave is not a stream, and in open water, or in a great ocean, has no effect in impelling vessels onward. It only becomes a stream as it enters and runs up narrow channels. In the absence of land, the tide-wave would complete its course round the earth in twenty-four hours, but would be hardly perceptible anywhere. Interrupted as its course is, the wave becomes very distinct, though still small, in the Atlantic, and as it passes along the coast of England, and through the British Channel and German Ocean, it sweeps onward, in some places advancing and retiring four times a day, and occasionally rushing in or receding with great velocity. The main tidal wave, which takes little more than twelve hours in travelling from the shores of Australia to those of Africa, takes nearly as much to reach the Canary Islands, and four hours more to arrive at the mouth of the British Channel. It there divides, part goes up the Irish Sea and round Great Britain into the North Sea, and part up the British Channel to the

German Ocean. Thus are produced local tides, and sometimes double tides, and the phenomena become more and more complicated.

Besides the alternate motion of the tide rising and falling every few hours, but nowhere steadily advancing, there are also other and not less important movements of the water, some occasional, some perpetual. The former are due to occasional winds, whose action lifts the surface of the water, and after a time effects a definite system of waves. These are wind or storm waves, varying according to the force of the wind. They are sometimes so powerful as to risk the destruction of any ship exposed to them. They rise to a great height—occasionally as much as forty feet—and the tops or crests break and fall over with terrible force. Storm waves drifting in shore over water gradually shoaling are magnified to a much greater extent, and are often destructive not only to ships exposed to them, but to the cliffs themselves against which they beat. Nothing can resist their violence.

But most remarkable of all are those stream currents—rivers of salt water running between banks and over a bottom of salt water—of which a very wonderful and well-known example is seen in the *Gulf Stream* of the Atlantic. This stream, whatever its previous history may have been, may be best understood when traced from the Gulf of Mexico, to which it owes its name. It issues thence as a stream of hot water, originally set in motion by some causes we cannot yet fully understand, and running through the narrow channel formed by the Bahama Islands and the coast of Florida at the rate of nearly five miles an hour; its width being there more than 30

miles, and the depth estimated at 1,200 feet. This vast stream widens, shallows, and slightly cools as it passes northwards along the shore of North America. It then turns eastward, and passing Newfoundland, crosses the Atlantic towards the European coast. Constantly widening and becoming less deep, diminishing in its rate of progress and becoming cooler as it runs on its course, this magnificent current continues to be a warm stream, limited in width and depth, and travelling steadily onwards. As a current it is lost long before reaching the shores of Europe, but its influence is felt, inasmuch as from it arise the south-westerly winds that tend to warm the west coast of Europe and the islands. There can be little doubt that in this way the Gulf Stream conveys a large amount of heat, and gives to a large area on the west coast of the Atlantic a more moderate and equable climate than would otherwise belong to it; a climate much more moderate than that of places in similar latitude on the opposite shore, or on either shore of the Pacific Ocean.

There is no current in any of the oceans so important, or in every way so well marked, as this, but there are many that are sufficiently powerful and influential to deserve notice. They exist in all large seas to some extent. In the Atlantic, besides the Gulf Stream, we find a cold Arctic current bringing down cold water and ice from the pole to the shores of America; a hot equatorial current from the coast of Africa, part of which enters the Caribbean Sea, and part runs down southwards along the coast of Brazil; and a cool Guinea current from the entrance of the Mediterranean, close to the African coast, as far as the equator.

The Pacific Ocean also has its currents. There is the main equatorial from America to Asia ; an Antarctic cold current running north-eastwards from the South Polar seas ; the Japanese current, representing, in a very modified form, the Gulf Stream ; and the Mexican coast current from California to Panama, varying with the season. There are others connecting these with each other, or with the Atlantic on the one side, and the Indian Ocean on the other. The Indian Ocean receives the equatorial current, and conveys it as a drift between Madagascar and the main land of Africa, and so round the Cape of Good Hope to the Atlantic. There are also many local and less important streams in various parts of the great ocean and in many of the inland seas.

By means of all these currents the great body of water in the ocean is kept in a state of circulation, for, unlike the tidal wave, which can at most mix the waters of the surface with the deep water, these stream and drift currents convey large bodies of water from one part of the ocean to another. Thus the warm waters of the equator are carried to distant shores, warming the air and equalizing the climate of the continent they approach. On the other hand, the cold waters of the polar seas come down into warm latitudes, cooling the air and rendering climates temperate. Everywhere the result is seen on the adjacent land ; and it is in this way that various lands having different climates differ also very greatly in their vegetation and their animal life.

There is, however, no reason to doubt that the direction and force of most of these currents has been greatly influenced, if it has not been originally caused, by the form of the land, and that in this, as

in other ways, water reacts on land and land on water. Owing to the great and beneficent law of nature, that there shall always be a supply of vegetable and animal life fitted to the existing conditions of climate, the earth is thus peopled, and the circulation of life kept up in connection with the circulation of water. And we shall presently see that the circulation of the atmosphere, and of water through the atmosphere, is intimately connected with the working of this important law. We need not in this place stop to inquire the ultimate cause of these movements of water and air. We must become familiar with the facts and their consequences before we can understand all the obscure and varied forces that have acted to produce them. Probably the motion of the earth from west to east in its daily course, and the hanging back of the water, owing to friction, may determine the small stream known as the main equatorial current, which is in some sense the parent of all currents; and then the form of the land and its position, the motions of the water produced by great differences of temperature, the much greater evaporation over some parts of the water surface than elsewhere, and the quantity of fresh water brought in by rivers, may explain most of the phenomena.

It is known by observation that the temperature of the water in warm seas is lower at some depth than near the surface. Near the Equator in the Indian Ocean, thermometers sent down to a depth of 1,800 fathoms (more than 10,000 feet) registered $33\frac{1}{2}^{\circ}$ Fah. In northern seas (in lat. 35°), below the Gulf Stream, at a depth of 1,000 fathoms, the temperature was 37° . Elsewhere it is still lower; and

it would appear generally that when the surface temperature of the sea is above 28° there are depths at which it is below that. It does not necessarily follow that the temperatures recorded are those of the sea bottom. They may refer to zones of cold water passed through.

On the other hand, in high latitudes and near the poles, the water is warmer in the deeper parts of the sea than at the surface. In a fluid like water the great and permanent differences of temperature that have been observed are presumed to be due to the existence of warm surface-currents setting from the equator towards the poles, and returning in a cooled state at great depth from the poles towards the equator.

The temperature of the surface of the sea varies little in the same place at different hours of the day, and not much at different seasons of the year, except near the shore.

Such are some of the special peculiarities of the ocean. In its magnitude, its depth, its regular streams and currents, its occasional disturbances by the wind, its saltness, and its tides, it is recognized as a part of the earth not only important in itself, but influencing, in an extraordinary degree, the land as the habitation of man and the lower animals. It is absolutely impossible to understand the nature of climate without a knowledge of this influence.

CHAPTER V.

SPRINGS, RIVERS, AND LAKES.

THE water on or within the earth's surface that does not form part of the ocean is either collected in large or small depressions, called lakes or pools, or it runs down from mountains and table-lands, through valleys into low plains, to enter lakes or the sea, in which case it becomes a river; or it circulates underground within the surface, and only issues at hill-sides or in plains or valleys as springs. The ocean, lakes of various kinds, rivers of all magnitude, and springs, include, therefore, the whole quantity of water on and in the earth. The total amount of surface occupied by these latter sources of supply is not very easy to calculate, but it is certainly very small indeed, even compared with the area of land, and therefore still more inconsiderable in reference to the earth's surface. Including everything, they can hardly reach three quarters of a million of square miles, covering not so much probably as four parts in a thousand of the earth's surface, while nearly eight hundred parts of the thousand are covered by the ocean, and the remainder (nearly two hundred) are land. The four parts we have now to consider rest on the surface of these two hundred.

The sheets of water on the land, and of course the rivers, are generally above the level of the sea, but there are some remarkable exceptions. We may divide the lakes into two groups—those above and

those below the level of the sea. Or we may divide them into two other groups—those containing fresh water and those containing salt water. Of the former there are several of considerable magnitude, but the whole number of salt lakes whose area is more than a few square miles each, does not amount to fifty. Most of the depressed lakes are of salt water, but as all lake water, and indeed all river and spring water, contains a certain proportion of solid matter, it is only by comparison that some are called fresh. By salt lakes the geographer means those that are salt to the taste. Some of them are exceedingly loaded with saline matter, while others are only brackish, and even occasionally drinkable.

The origin of lakes may be either the filling up of a natural depression by water derived altogether from rivers and springs, or it may be that the sea has not only once occupied the bed of the lake as it now exists, but covered the land between it and the ocean. In this latter case the evaporation of pure water from the surface will ultimately dry the lake, leaving a salt marsh or salt deposit, unless the water evaporated be replaced by spring or river water. But the quantity of spring or river water entering is likely to be either more or less than the evaporated quantity, for it is hardly possible that it should exactly balance the loss. Thus, in salt lakes there is a tendency either to become saltier by a loss of their water, the solid contents remaining the same, or to become fresher, if the streams running into and through them are considerable. Salt lakes and fresh water lakes form but one phenomenon, and are both derived from and connected with springs, rivers, and the ocean.

The origin and history of rivers is different. They are partly composed of the waters that have fallen as rain on high ground, and run immediately, by the force of gravity, to a lower level, till they reach the sea. They take their rise in some cases from the ice that has been accumulating during winter, and which melts when warm weather comes, and in other cases they are derived from, or increased by, the water issuing from the earth as springs.

To understand and appreciate the circulation of water on the earth, it is well to begin by considering the rain as the ultimate source of supply, the water being constantly drawn from that great reservoir the ocean, conveyed to a distance by clouds, and dropped upon the earth in rain. A part of the rain that falls enters the earth, and comes out again in springs, and another part runs over the surface.

Of natural springs there are three kinds: (1) land springs, obtained from accumulations of water in shallow pools under the surface, and rarely issuing naturally; (2) springs coming out from between certain kinds of rocks, having a temperature comparatively cool in summer and warm in winter; (3) mineral springs, coming from very great depths, and of the same temperature all the year round. Most of these are warm, and they are then called thermal springs. They are sometimes loaded with mineral matter of various kinds. The springs that are the largest in quantity, and the most numerous in most parts of the world, are of the second kind. They rise in valleys, and even in the beds of rivers, bubbling up with great force. They also break out freely on hill-sides. Many of them give a supply which is so uniform in temperature and regular in

quantity, that they evidently come from a great depth, and are independent of seasons. Very frequently the part of the year when the supply of water from such springs is smallest is the early spring, when the rains are heaviest, and it is a common saying in some parts of the country, that "as the days lengthen the springs strengthen."

Springs of water are much more common in some kinds of rock than in others. Water often comes out from every crevice in limestone rocks; it also issues in abundance from hard sandstones under certain circumstances. In clays it rarely appears in this manner. Springs are common wherever hard tough rocks appear, and alternate with loose sands. The water, not being able to pass through the former, is carried along the latter as through a tube. The quantity issuing from some springs amounts to two or three millions of gallons a day, but these are very rare; and most of those that issue even in England, where the quantity of rainfall is considerable, yield less than a million gallons. Artificial borings or wells sometimes liberate water existing under pressure, and produce powerful springs, available for human purposes. Such water is generally pure.

Mineral springs, though common enough in most parts of the world, are especially numerous and abundant near volcanic districts, and where granite and rocks of that class are in contact with slates and sandstones regularly stratified. By their agency vast quantities of mineral matter, chiefly carbonate of lime (or limestone), are removed from the interior of the earth and brought to the surface. The waters of the ocean contain about five ounces of solid matter to the gallon. Some mineral waters do not contain

more than the twentieth part of an ounce; others contain sixteen ounces.

The temperature of water issuing from the earth must be nearly the same as that of the rocks through which it passes. There is always a certain depth below the surface where the changes of summer and winter are no longer felt, and the temperature is that which corresponds to the average heat of the surface. This varies in every latitude, and thus the temperature of water from deep springs becomes, within certain limits, an indication of the depth of the source. The deeper the source the warmer the water, as the heat in the interior of the earth increases pretty regularly below a certain depth. This, however, does not prevent the surface waters in volcanic districts from coming up almost in a boiling state. Boiling springs are rare, and occur only where there are volcanoes. The hottest springs coming up from a great depth do not exceed 180° F., as they are cooled down to some extent while making their way to the surface. Hot water conveys a large quantity of silica or flint, which is left behind when the water cools. Cold waters generally convey carbonate of lime.

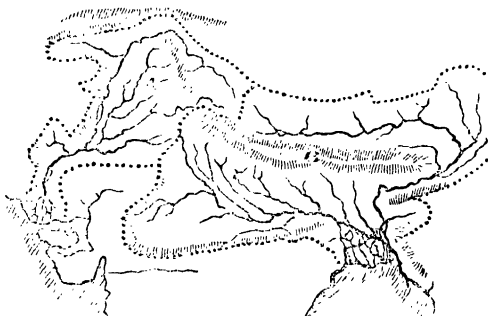
The minerals contained in mineral springs vary exceedingly, and the proportion of each varies also very much. The salts of soda, lime, and magnesia are the most abundant; iron is exceedingly frequent, and carbon (partly in the state of carbonic acid gas) is both abundant and frequent. Some springs are like natural soda-water. An idea may be obtained of the large quantity of water rising to the surface, and of the quantity of solid matter removed from the interior in this manner, by knowing that, in the waters

of Carlsbad, in Bohemia, about 15,000 tons of sulphate of soda are brought every year to the surface; and that in a small district in the centre of France, where the average of solid matter is very small (less than an ounce to the gallon), the quantity of carbonic acid gas rising in a year would weigh nearly 400 tons, and the total solid matter 16,000 tons.

Rivers (including, under this general name, all the smaller streams and brooks of every kind that feed them) are exceedingly important in Physical geography, and it is convenient to describe them in groups. A group, consisting of a great river with all its tributaries, is described as a river system. The district which supplies the water to feed such a system is usually well marked by nature, for water always flows downwards, and by following each branch of a stream to its source, we obtain a succession of points on either side of which the water flows a different way. Such a line is called a *watershed* or water-parting, and the country included between the watershed and the line of coast near the mouths of a principal stream is called the drainage area of the river, or sometimes its river basin. Every river system has a watershed and a drainage area, and the object of the Physical Geographer is to determine the position of all these lines and areas, and thus divide a country or sea-coast into as many drainage areas as there are principal rivers. These are not so numerous as might be supposed, and the great river systems of the earth are easily known and remembered. The annexed diagram, illustrating the river systems of two of the largest river systems in the Old World, illustrates what has been here said. There are some rivers, such as the Nile, the Mississippi, the Amazon,

and the Plata, of which the principal stream runs for a distance of several thousand miles, and each of whose drainage areas includes more than a million

FIG. 10.—RIVER SYSTEMS.



A.—Basin of the Indus. B.—Basin of the Ganges and Bramaputra.
N.B.—The dotted line marks the watershed.

square miles. There are many others, of secondary importance compared with these, but in which the total length of the principal stream exceeds a thousand miles, and their drainage area half a million of square miles. These all drain large continents, and have tributaries, which, under other circumstances, might well rank as first-class streams. The list of familiar and important streams numbers nearly a hundred, and of these very few indeed drain a smaller area than 20,000 square miles. In estimating the length of a river, the "direct course" is the nearest distance in a straight line to the sea, and the total length of course the length of the principal stream including its windings, but not including any tributaries or branches.

The river systems are grouped, not so much with

reference to the land they drain, as the ocean into which they drain. Thus we have the Atlantic group, the Pacific group, the Indian Ocean group, and the Arctic group. Small as the Atlantic Ocean is, compared with the Pacific, it receives the drainage of a very much larger group of streams. Europe, almost without exception, drains into it, the rivers either running directly into the ocean, or reaching it indirectly by the Mediterranean and Black Sea, and the Baltic. By far the most important of the African river systems—that of the Nile—belongs also to the Mediterranean. All the vast streams of the two Americas are turned into this great channel, owing to the position of the mountain chain on the western side of the continent, and the wide expanse of moderate slope on the east. Only a part of Asia belongs to the Pacific Ocean, a much larger part emptying into the Indian Ocean, while another large part pours northward into the Arctic Ocean. Of America, the only important streams entering the Pacific are the Columbia and the Colorado, which together do not drain half a million of square miles. The rivers of Africa enter the Atlantic or Indian Ocean. Compared with the Pacific, both the Indian and the Arctic Oceans receive numerous and large streams, and the drainage of large tracts of country.

The result of this arrangement of the land, and its effect on the direction of the streams that convey the rain back to the ocean, is manifest in many ways; but the direct effect that might be looked for by the greater influx of fresh water, in proportion to the area of the ocean, and the reduction of the saltiness of the Atlantic, compared with the Pacific, is counteracted by the greater amount of evaporation that

takes place, and the fact that most of the water raised by evaporation is carried away towards the land, whereas in the Pacific it returns to the ocean. The currents that enter the Atlantic, bringing salt water, are also much more important than those of the Pacific.

Very few rivers run from their principal source to the ocean, without being joined by tributaries, many of which may be as important as the main stream; and if the length of course of the tributaries were added to that of the main stream, it would multiply many times the apparent magnitude of the stream. There are also, besides the rivers that feed the great streams, a number of others emptying into the sea on the coast between two principal drainage areas, which do not enter into calculation. The total amount of drainage areas is thus much smaller than the total area of land.

The European rivers of the Atlantic system include (1) those entering the open ocean; (2) those entering the Baltic; and (3) those entering the Mediterranean from the north. The streams entering from the great islands, especially the British islands, must also be added.

It may be convenient to the student to be reminded of the most important of the streams that traverse the European continent. They are as follows:— (1) Elbe and Rhine (draining 143,000 square miles); Seine, Loire, and Garonne (110,000 sq. m.); Douro; Tagus, Guadiana, and Guadalquivir (115,000 sq. m.). These, with the Thames (6,500 sq. m.), the Severn (5,500 sq. m.), the Humber (10,000 sq. m.), the Shannon (7,000 sq. m.), and other British and Irish streams, and the Weser (17,500 sq. m.), make up

the list of those communicating directly with the ocean. The Neva, Vistula, Oder, Dwina, and Niemen (total, 305,000 sq. m.) enter the Baltic. The Elbro, Rhone, and Po (110,000 sq. m.) enter the Mediterranean, and the Danube, Dnieper, Don, and Dniester (791,000 sq. m.), the Black Sea. Of these the Danube is much the largest, running for about 1,000 miles in a direct line from its principal source, and draining 310,500 square miles. The Dnieper and the Don are next in order of magnitude, and are larger than most of the European streams. We thus have three of the largest European rivers communicating, not with the ocean, but with a lake at the extremity of a great inland sea. It is not extraordinary that the waters of this sea are less salt than the Atlantic. The same result, due to a similar cause, has been observed with regard to the Baltic, for, although the rivers entering it are much smaller than those of the Mediterranean, they are more numerous, and are all of nearly the same magnitude.

Besides the rivers here named, the great Nile, bringing the drainage from Central Africa, having a total course of at least 3,000 miles, also belongs to the Mediterranean system; and as this inland sea communicates with the Atlantic only by a very narrow passage, it becomes almost an independent ocean. The same is the case, to some extent, with the Baltic Sea. It has better access to the Atlantic, but its waters are much less salt than those of the Atlantic, owing to the excess of fresh water running into it, over the evaporation that takes place from its surface.

Several African rivers, one of them (the Niger) coming from a great distance in the interior, and others (Senegal, Orange river or Gariep, Gambia and

Coanza) draining the west coast, empty into the Atlantic, and help to supply the vast losses that take place in the equatorial regions by constant evaporation. But these rivers, though by no means unimportant compared with European streams, are trifling, both in volume and drainage area, compared with the American rivers. In North America the Mississippi-Missouri, a combination of two first-class rivers, drains nearly a million and a half of square miles, and, although its sources are only 1,600 miles in a direct line from the Gulf of Mexico, the length of course of its longer branch, the Missouri, including windings, exceeds 4,000 miles. Some of its tributaries, as the Ohio, are rivers of large size and great magnitude. This stream alone runs nearly 1,000 miles. The Mississippi finally enters the Gulf of Mexico in the hottest part of the ocean. The Rio del Norte and the Magdalena enter the Atlantic from the south-western part of North America; the former, after a run of 2,000 miles, including windings; the latter about half that amount. The two drain 350,000 miles of country. Besides these, several streams of importance enter the Atlantic directly from North American land, of which the St. Lawrence is much the largest. It drains 400,000 square miles, and runs more than 2,000 miles. Its direct course from the source to the sea is about 1,000 miles.

But it is chiefly the vast expanse of South America, consisting almost entirely of great plains, sloping from the Andes to the Atlantic, that supplies the great store of water feeding the Atlantic canal. The Amazon, taking its rise in the Andes, runs nearly 1,800 miles in a direct line from its source to the sea, through a vast extent of country; and, with

its tributaries, drains more than two millions of square miles. Many great streams, known under different names, and draining large districts, combine their waters before the name of Amazon is given to the final stream, which, where it enters the sea, is more than fifty miles wide. So large is the stream, that the tide runs up more than five hundred miles, reaching several of the principal branches before its effect dies away. The Amazon, by a natural canal in one of its upper branches, communicates with the Orinoco, another great stream draining between three and four hundred thousand square miles. The sources of the Orinoco are so near those of the Plata—the second in importance of the South American rivers—that the waters mix, and canoes can be paddled from the basin of the one river to that of the other. From this it is evident that the watershed of a river system does not necessarily cross high land, but must occasionally be drawn through a plain, or even through a lake or pool.

The Plata is a magnificent stream, whose sources are about 1,200 miles in a direct line from the outfall of the river (nearly 2,500 miles, including windings). It comprises several large and important streams, draining a million and a quarter of square miles of the interior of South America. Between the basin of the Amazon and that of the river Plate (Rio de la Plata) is a district of nearly a million square miles, drained by several rivers, of which the Tocantins and S. Francisco are the principal. These each run more than a thousand miles from their sources to the sea, without including windings.

The Atlantic thus receives the drainage of upwards of ten millions of square miles of country, pouring

in by nearly twenty rivers of first-class size, nearly double that number of great rivers of the second class, and a vast number of smaller streams, each larger than any of the rivers of England, whose drainage areas are all less than ten thousand square miles. Many of these streams bring down large bodies of fresh water to mix with the salt waters of the sea. Others hardly reach the sea as rivers, though performing an important part in nature and entering lakes which have no present communication with the ocean, although in former times they may have existed under different conditions.

The Pacific receives from the Asiatic side some of the Chinese rivers, and from North America the Columbia and Colorado, together draining about half a million of square miles.

There are three principal Chinese streams, each draining more than three quarters of a million of square miles, and having a direct course, varying from thirteen hundred to seventeen hundred miles. There is a fourth, much smaller, but still considerable. The actual course of these streams, including windings, is, in each case, about double the direct distance of the source from the sea. Besides these, there are no streams of importance entering this vast tract of salt water.

The Indian Ocean receives the great rivers of India and the drainage of the east coast of Africa. The Ganges and Bramaputra, the Irawadi, and the Indus drain a million and a half of square miles, and the length of course of each, including windings, exceeds 2,000 miles. The Euphrates runs 1,800 miles, and drains 260,000 square miles of country. The Menam is still larger, and there are others

somewhat smaller. The African Zambesi, though a first-class river in the great length of its course, delivers but a small quantity of water.

The Arctic Ocean receives from the Old World the drainage of nearly four millions of square miles, comprising almost the whole of Asia north of the great mountain chain, and also the drainage of a million and a quarter square miles of American land. There are ten great Asiatic rivers, three of them of the first class, running nearly 3,000 miles each. These are the Obi, the Yenesei, and the Lena. Of the American rivers two only, the Saskatchewan and the Mackenzie, are important, one running about a thousand miles, the other more than twice that distance. The Dwina and Petchora (European streams) and the other rivers are smaller. There is no land whose drainage areas are known within the Antarctic circle.

The rivers of Australia are few in number, and small compared to the area of the land drained by them. The Murray is the only important stream. It receives many large tributaries, and has a winding course of about 1,300 miles, near the east side of the Australian continent, draining about half a million of square miles, and emptying into the Indian Ocean.

Besides the rivers that enter the ocean, there are some that enter lakes, from which there is no communication to the sea. The Volga, a noble stream, and one of the largest of Europe, enters the Caspian Sea, after running nearly 2,800 miles, and receiving important tributaries. The Ural, another important stream, also enters the Caspian, and so does the Kur or Cyrus river. These three streams drain an area of nearly three quarters of a million square miles.

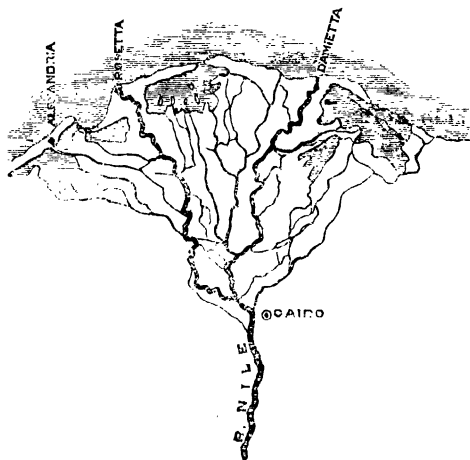
Most of the great lakes have outlets, and communicate with the ocean ; and many of them are expansions of river beds. Besides the Caspian Sea, Lake Tchad is another example of a lake receiving drainage but not having an outlet. The Sea of Aral, Lake Balkash, Lake Baikal, and Lake Lob, in the great plains of Central Asia, all receive rivers, some of them of considerable magnitude ; but no water issues from them. The whole of the interior of Asia between the watershed of the Obi, the Yenesei, and the Lena, and the Himalayan mountain chain, is received into lakes that do not communicate with the sea.

The phenomena of rivers are numerous and varied, and require to be carefully studied ; and of all varieties running streams are perhaps the most interesting. Rivers collect and convey the water that falls from the clouds as rain. Without exception they are fed by many tributaries, have many branches, and help to render large tracts of the earth's surface fruitful and habitable. Rivers in all their stages, whether as brooks, small streams, or mighty rushes of water pouring into the sea, discolouring its waters for miles, are among the most important agents of nature. They often destroy and always carry away part of the land through which they run. They also help to renew the face of nature by making fresh deposits and extending the land beyond its former limits by means of the mud brought down. Some run between high cliffs or bluffs, having cut out a channel through the rock. Some rush over hard rock, tumbling over precipices, or noisily forcing their way through difficulties. Some sink underground and perform an important part of their courses out of sight. Some enter lakes and are

not seen to emerge; others make use of lakes only as resting-places, entering as rapid turbid streams, and passing out quietly after depositing all their impurities.

A few examples of some of these results of river action may here be useful. In Sicily, near Mount Etna, there is an example of a river having made its way through a solid lava current, cutting a passage fifty feet deep, and several hundred feet wide, within the last two centuries. It is seldom possible to measure the rate of progress, but that, when circumstances are favourable, it is very rapid, there is no doubt whatever.

FIG. 11.—DELTA OF THE NILE.



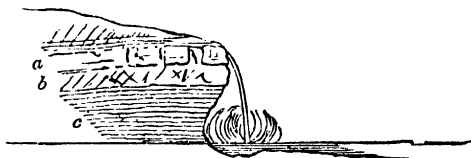
The deposits of mud at the mouth of a river, conveyed down by the stream during its progress from the mountains to the sea, are occasionally very large.

They are called deltas, that being the name of the Greek letter Δ , which represents the triangular shape of such deposits. One of the most remarkable is the delta of the Nile, which commences about a hundred miles up the stream from Alexandria, and has a breadth of 230 miles at the sea. The river has been depositing this mud for a very long time. Each year some is left behind at the point where the rate of the stream is checked before it reaches the sea. When one mouth is choked up, another to the right or left is formed, and thus by degrees the width of the deposit is increased, and the stream, instead of entering the sea where it originally did, is obliged to pass over a long distance, covered by the mud it has deposited. The Ganges has a delta, whose dimensions are still larger than those of the Nile. It commences 220 miles from the sea, and its breadth is nearly 200 miles. The Mississippi delta commences 200 miles from the sea. The great rivers of Europe also have deltas. The whole of the flat land of Holland is a part of the delta of the Rhine. There is a tract of 320,000 acres of flat land, which is the delta of the Rhone. The Danube also has a large delta. It has been calculated that the quantity of solid matter brought down by the Rhine, on an average of all the year, is at the rate of about 400 tons per hour. The total annual deposit made by the Ganges has been estimated as more than six thousand millions of tons. When we consider the number of the rivers, and the never-ceasing action of this cause, we shall learn to recognize its value.

Many rivers run for some distance over ground having only a gentle slope, and then suddenly leap over a precipice, or are forced through a narrow

channel of loose hard rock, on a considerable slope. Thus are produced waterfalls and rapids. Waterfalls, in the case of great rivers, are rare, but there are

FIG. 12.—WATERFALL.



a, b.—Hard rock, worn slowly. *c.*—Soft rock, excavated by water.

some of surpassing grandeur. Niagara, in North America, the Zambesi, in Central Africa, and a group of falls near the great lakes at the source of the Nile, are the largest known. There are others of smaller proportions, but very striking, and more accessible to Europeans. Among them the falls of the Rhine at Schaffhausen occupy the first place, but the fall is only sixty feet. There are much higher falls, but of small bodies of water—in Switzerland, Norway, and, indeed, in most mountainous countries; and many of these are remarkable for the enormous distance through which the water descends, in one or more leaps. This, in some cases, approaches 1,000 feet. The Falls of Niagara include a breadth of water of about 1,400 yards, the leap of the water being, in the principal division, as much as 162 feet.

In most cases the motion of a river is produced by a very moderate average fall, the slope of the river bed reducing gradually towards the plains, and being often scarcely appreciable for many miles near the

outfall to the sea. The velocity of a river is, therefore, not altogether in proportion to the immediate fall. During the 700 miles of the Amazon's course, nearest the sea, the slope is barely distinguishable, amounting only to twelve inches in all. This is nearly level, but in its previous course the water has acquired a velocity considerable enough to carry it to the sea with a rapid stream.

An average slope of twelve inches in a mile admits of a large river running in a torrent along its bed through its upper valleys, falling in a leap, and rushing over rapids, its course terminating in a steady navigable stream. A smaller river, having an average fall of forty feet per mile, may hardly show any difference in this respect, the greater part of the fall occurring in the upper valleys where the stream is a torrent. Two or two and a half miles per hour must be regarded as a considerable current, and many large and important rivers have not for a great distance an average rate of one mile per hour.

Many rivers are mere torrents shortly after rain, and at other times are almost dried up. This condition is especially the case with rivers that run through table lands. But all rivers convey water irregularly, the quantity being sometimes much greater than at others. The mechanical effect of a stream can only be judged by that of the largest body of water that comes over its bed, and the speed at which the highest water travels. Thus rivers that generally appear unimportant, but are subject to heavy floods, are more really influential on the surface than much larger streams running almost all the year at the same rate. Some rivers are strictly seasonal in this respect, rising almost at the same date and nearly to

the same height every year. Others vary much in date and amount, but have a certain amount of regularity. Others again are altogether irregular. The Nile is a well-known example of regularity of flood. The river begins to rise at the head of the delta about the end of June, and continues to increase till the end of September, when the whole of the flat country is generally quite under water. After remaining for a few days, it gradually retires.

The great rivers of India are subject to occasional floods. Rivers that pass through lakes, or through wide open spaces that allow the water to expand, are less subject to danger from these sources than those whose channel is clearly defined. Excessive or periodic rains generally cause floods.

Lakes are not always expansions of river beds, but may be portions of a former ocean. This has been already explained at the commencement of the present chapter. They are special phenomena, and must be referred to accordingly. They occur to some extent in most countries, but it is only those of large size and permanent importance that we can here consider, and these are greatly limited.

Almost all the salt lakes of any magnitude occur in a vast tract of land of considerable elevation in some places, but much below the sea-level at others, extending north and west of the great mountain chain, running through Asia, and occasionally among the ridges of this chain. Of the whole number the Caspian Sea is by very much the largest. It occupies a part of a depressed plain, the Sea of Aral occupying another part, and the level of its water at present is eighty-three feet below the level of the Mediterranean. Its area

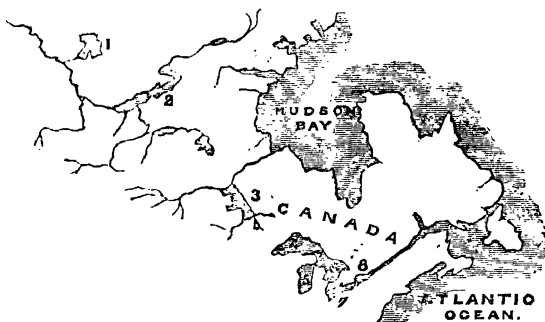
(estimated at 130,000 square miles) is greater than the areas of all the other salt lakes on the earth put together. The Sea of Aral, filling part of the same depression, is at a much higher level, and is one-fifth part the area. The Dead Sea is depressed very much more, being 1,300 feet below the Mediterranean. There is a small salt lake in Abyssinia said to be 570 feet below the sea level.

While some of the salt lakes are much below, others are at a great elevation above the sea-level. In Persia and Turkey there are several large sheets of salt water, four or five thousand feet above the sea; the Great Salt Lake of the United States is also 4,000 feet; and there is a salt lake in Bolivia more than 12,000 feet above the sea. The Platten Sea, in Hungary (a salt lake) is nearly 1,000 feet above the sea.

Of fresh-water lakes, those of North America are by much the largest. They form a chain commencing near the Rocky Mountains, where are the Great Bear (1) and Great Slave Lakes (2) (each about 14,000 square miles), communicating by the Mackenzie river with the Arctic Ocean. There are five more large lakes between these and the great group, of which Lake Winnipeg (3) is the largest. These all connect with the northern waters. Lake Superior (4) (400 miles long and 175 miles wide), Lake Huron (5) (almost as large), Lake Michigan (6), Lake Erie (7), and Lake Ontario (8), come next. Their position is indicated in Fig. 13 by figures referred to in the above list. The latter five all belong to one system of drainage, communicating with each other, and emerging below Lake Ontario, as the St. Lawrence river. They cover nearly 85,000

square miles, and the Great Niagara Falls are those of the Niagara river, which connects Erie with Ontario. The upper lakes are about 600 feet above the sea, and the lower lake, Ontario, less than 240.

FIG. 13.—NORTH AMERICAN LAKES.



Next to the North American lakes are those of Africa, recently discovered, but now well known to occupy an important position in the general physical geography of that continent. These are several in number, situated on a high table-land, and probably connected. Tanganyika is very large, and is close to the equator. It is 300 miles long, and 60 miles across at the southern end. Lake Nyassa is some distance to the south, and is 200 miles long. The Victoria Nyanza is about 200 miles from north to south, and 300 from east to west. The Albert Nyanza is near it, and is 350 miles long and 100 miles across. Lake Tchad is a large pool on the western side of Africa, very shallow, and varying much in its magnitude and appearance, according to the time of the year at which it is visited and the season.

Asia contains Lake Baikal, a large and important sheet of fresh water in Siberia, and a vast number of much smaller lakes in China, Chinese Tartary, and Tibet. It also contains one very small pool (Sir-i-kol, in Turkestan), 15,600 feet above the sea.

Europe is very rich in lakes, but none are either very large or situated very high. There are several groups. The Swiss and Italian lakes, though not the largest, are so well known and so wonderfully beautiful, that they deserve first consideration. The lakes of Geneva, Lucerne, and Constance, on the north, and the lakes of Como and Garda and the Lago Maggiore on the south side of the Alps, are generally known. The Russian lakes, of which Ladoga is the chief, and the lakes of Sweden (Wener, Wetteren, &c.) form two other groups. The small but picturesque lakes of Ireland, Scotland, and Wales are familiar and interesting from their proximity. They are most of them connected with running streams. Lough Neagh, in Ireland, contains 150 square miles, and is the largest. It belongs to another class. The Lake of Geneva, in Switzerland, is 260 square miles. Loch Lomond is 45 square miles; Windermere about 11.

Spain and France are almost without lakes, but Eastern Germany, Bohemia, Gallicia, and Moravia contain many thousand small pools. Italy, also, contains several, chiefly occupying the craters of old volcanoes.

Northern Europe is covered with sheets of water, and in Sweden and Finland the proportion of water to land is large. Lake Ladoga, in Finland, has an area of 6,500 square miles. It is connected with Lake Onega, about half the area, and the two con-

nect the waters of the Neva. Lake Wener, the largest of the Swedish lakes, is more than 2,000 square miles.

Most of the lakes occupy natural depressions in the land, caused, perhaps, in some cases by the mechanical action of water or ice. Concerning the origin of other lakes there is great difference of opinion. Many large sheets of water are shallow, and comparatively few are so situated that even their deepest parts are much below the level of the sea. But there are very important and remarkable exceptions to this general rule, and there are some places on the earth where a natural convulsion or a small change in the level of intervening land might cause the sea to rush with resistless force over the obstacles that at present keep it back, and overwhelm vast tracts of land now cultivated and inhabited. Such an incursion would be a true deluge, and might destroy not cities only, but countries.

CHAPTER VI.

THE ATMOSPHERE.

THE atmosphere is the name given to the invisible film of air which entirely surrounds our earth, which partakes of its daily motion on its axis, and which accompanies it in its journey in space. Compared with the mass of the earth, it is very small. It has been compared, not unfairly, to the down on the skin of a peach, and certainly it is not greater in proportion. It is exceedingly elastic, so that near the earth its density, or the weight of the quantity contained in a given space, is very much greater than a few miles above the surface. At the tops of mountains 12,000 feet high it is only half as dense as in the plains and on the sea-shore. Its total height is not easily estimated, as it no doubt thins away into the ether that occupies all space. It is recognizable in its effect on light at a distance of more than fifty miles from the surface; and probably up to or even beyond 100 miles similar effects still take place. It appears to affect the passage of meteors moving 200 miles from the earth's surface. The changes that produce winds and storms, the phenomena of dew, clouds and rain, and other conditions that affect climate, all take place within a moderate distance of the earth.

The air consists of a mixture of gases. In a given quantity of common air, about four parts in five are nitrogen, and one-fifth oxygen gas. By weight the proportions are rather different, as

oxygen is a little heavier than nitrogen. These gases are simply mixed together, and mixed with them there is always a little carbonic acid gas. Of this, however, the proportion is only about four parts in a thousand. The mixed gases forming the atmosphere are able to absorb a very large quantity of vapour of water, the quantity that can be held without appearance of vapour varying according to temperature. The vapour atmosphere, as this is sometimes called, may be considered, and its effects traced, almost independently of the atmosphere of dry air; but the two principal gases, the carbonic acid gas, the vapour, and numerous other substances, of which exceedingly small quantities have been discovered, all exist together at all times in very nearly the same proportion, and all act together in reference to changes that are constantly taking place.

Of these changes, two are very marked and easily understood, and are also highly influential in all that concerns climate and weather, and the use of the atmosphere to living beings. They are changes of temperature and changes of pressure. The air has not long together the same warmth or cold, nor does it press equally over all parts of the earth, or on the same place at different times. This is greatly owing to its elasticity and its expansion when heated. Air is exceedingly elastic. When pressed upon, either by a solid or fluid, or by a large quantity of air above, it yields to the pressure and occupies for the time a smaller space. When heated it also occupies a larger space, and if cooled it shrinks into a smaller. Afterwards, when the cause is removed, it passes back readily and perfectly to its original state. So much of the peculiar influence of the atmosphere

depends on these conditions and properties, that the student of Physical Geography requires to have a clear notion of them. The changes are measured by instruments. Changes of heat by a thermometer, a column of quicksilver or coloured spirits of wine, connected with a reservoir; the fluid in the reservoir expanding with heat and sinking with cold, and the column rising or sinking, in accordance with these changes. Alterations of pressure are measured by a barometer, either a column of mercury in a long glass tube, with no air at the top, balancing exactly the weight of the whole of a column of air the full height of the atmosphere, and of the same area; or a copper box with a thin lid, the air being removed from the inside of the box. In either case the pressure of the whole column of air is measured. In ordinary cases, at the sea-level, it is equal to about fifteen pounds to the square inch; and as a column of mercury an inch square and thirty inches long would weigh about fifteen pounds, this is the usual height of the column. It varies within an inch or more on each side for changes at the sea-level, and diminishes steadily on rising, being reduced to one-half, as has been said already, at the height of 12,000 feet.

Measuring accurately the pressure and temperature of the air, the barometer and thermometer are instruments quite indispensable, and never to be neglected. Other instruments, almost equally important, show the condition of the air with regard to moisture, and measure the quantity of rain that falls. Observations on these points are the fundamental resources of this department of Physical geography.

The barometer, measuring the pressure of the air,

which we know to diminish with some regularity as we rise above the surface of the earth, heights may thus be measured. The pressure diminishes at the rate of about an inch of mercury for 800 feet of rise. But as in ascending into the air we diminish the pressure the boiling point of water becomes lowered,* and thus the thermometer becomes also available directly to determine the degree of pressure, and therefore the height. The lowering is at the rate of 1° Fah. for about 600 feet of rise.

The atmosphere produces certain important effects on the light and heat rays that arrive at the earth's surface from the sun. Of rays of light it always absorbs some proportion, but much less when the rays fall directly than when they are oblique. Of 10,000 light rays, 8,000 reach the earth if the sun is vertical, 7,000 if the angle be 50° , 3,000 if the angle be 3° , and scarcely any if the rays pass through a horizontal stratum of air. The eye recognizes this by the appearance of the sun at different hours of the day.

Besides absorbing certain rays, the air reflects others, dispersing them everywhere, and preventing that deep blackness of shadow that would otherwise be felt. The dispersion of light through and by the atmosphere tends to equalize the light everywhere. Twilight is an illustration of it. Much of the light that enters the air is bent downwards, or *refracted* by the different strata of air into which it enters,

* The boiling of a liquid is the sudden formation of steam, which rises in bubbles to the surface. The formation of such steam-bubbles is checked by pressure on the water, and rendered easier by the removal of pressure. Thus from the temperature of the boiling point of water we may calculate the elevation of a station above the sea-level.

and is broken up. It is thus coloured. The blue colour of the atmosphere near the sea is due, however, to the quantity of aqueous vapour present. At the tops of high mountains, when the sky is clear and the sun absent, the colour is black.

Heat passes freely through dry air, but is interrupted and absorbed by vapour. Thus radiation of heat from the earth is rapid when the air is clear, but is immediately checked when a cloud or vapour intervenes.

The barometer measures the weight or pressure of the whole air. If the atmosphere be moderately dry, and the air still, the pressure at the level of the sea is, as we have said, equivalent to about 30 inches of mercury. But if a part of the dry air is replaced by vapour, the pressure is diminished, because steam is lighter than dry air. Whenever, therefore, air is replaced by vapour in the atmosphere, the barometer, or rather the column of mercury in it, sinks; and in those places near the sea, especially in the torrid zone, near the equator, where the air is always loaded with vapour, there is a permanently low barometer. An addition of moisture, or rather the replacement of dry air by moisture, always diminishes the pressure of the air and lowers the barometer. It is important to remember this, as the familiar expressions of our language with regard to the state of the air would suggest the contrary. We all habitually speak of the air as feeling heavy, when the barometer is low and the pressure is diminished. We are told that the air is light and elastic when the pressure is at the greatest. These expressions accord with our feelings, but they do not agree with the results of observation.

Heat expands air, and causes it to rise from the earth towards the upper part of the atmosphere, producing a kind of wave, and resulting in a general advance of cooler air towards the place heated. On a large scale this is exemplified in the trade winds. The land within the Tropics is heated day after day by a sun nearly or quite vertical, and this heated air rises and flows over towards the temperate and frigid zones, while the cold air from those parts of the earth is drawn in to replace the heated air travelling away. The lower current of air thus produced, which would be a north or south current if the earth were still, is converted into an east wind, or nearly so, towards the equator, because of the motion of the earth on its axis from west to east. At the poles this motion is nothing; on the borders of the temperate zone it is only a few hundred miles per day; at the equator it is a thousand miles per day. The result of this is that by the time the wind, coming southwards from the North Pole, or northwards from the South Pole, reaches the equator, the point it would have reached has travelled eastwards a vast distance, and the wind arrives at some other point, appearing to have come from a point of the compass a little to the north of east. North-east winds blow throughout the year with much steadiness in the Atlantic, and periodically there are similar winds in the Indian Ocean and Pacific. They are called *trade winds* in the former, and *monsoons* in the latter sea. They blow on both sides of the equator, but are separated by a belt or zone of calms, about three or four hundred miles wide, very near the equator. In the Atlantic this zone is to the north of the equator, owing to the preponderance of land in the Northern

hemisphere. Its position is not fixed, and in the Indian Ocean it is hardly traceable.

Land and sea breezes are also regular winds. They are caused in hot countries on and near the sea-coast, by the action of the sun's heat, which is much greater on land than on water. Some time after sunrise, when the soil begins to be heated, the air, being also heated, rises into the upper part of the atmosphere, and is replaced by air from over the sea, which remains comparatively cool. This is the sea breeze. The heating of the soil continuing, the breeze continues during the day, but in the evening, after sunset, the earth begins to radiate heat, and soon becomes cooler than the water. The reverse now takes place. After a lull and calm for a short time, the cool air blows from the land towards the sea, and becomes a land breeze. In each case there are upper currents in contrary directions.

The upper currents of the air are chiefly discovered by observations made in balloons, or on the top of high isolated mountains. They are indicated also by the motions of clouds, and by the long distance to which volcanic dust is carried during eruptions in a direction different from that of the lower currents. The upper as well as the lower currents are liable to be diverted in their course by the high lands and mountain chains, and are affected by the continents and the principal islands. As a general rule, however, the prevalent winds in all latitudes between 30° or 35° N. and 30° or 35° S. are from easterly points, and in the rest of the world from westerly. There are exceptions in the case of the monsoons, as during the winter months these are easterly winds at latitudes north and south of 35° , and westerly

winds within these latitudes. This reversal is due to the land enclosing the northern part of the Indian Ocean.

Besides the regular winds, or, as they are more properly called, constant and periodical winds, affecting certain parts of the earth, chiefly near the equator, there is in each hemisphere a large tract within the temperate zone where the winds are variable. In these middle latitudes in the Northern hemisphere, where alone there is any great expanse of land, there is, however, more regularity than is sometimes supposed. In the North Atlantic, west winds prevail to such an extent, that sailing ships used to make an average passage from America to Europe in three weeks, while the passage from Europe to America averaged more than a month. The prevalent winds over the great continent in the same latitudes are north-east. Besides these there are a number of winds prevalent over small districts, which may be called local winds.

Winds blowing with unusual strength and rapidity become storms. There are various kinds of storms, some blowing steadily for a considerable time, with varying force, but little change of direction. These are called gales, if the violence is not extreme, and are sometimes accompanied by thunder and lightning. Other storms are limited to certain parts of the ocean or to certain districts. Of the former, spiral storms or hurricanes are the most remarkable. They are known under various names in different countries, and are now generally called *cyclones*, owing to the circular motion of the air when thus disturbed. They are most frequent in the West Indies, where they are called hurricanes, and in the Indian Ocean

and in the China seas, where the name typhoon is given to them. Storms of the same kind, but far inferior in violence, extend to other and distant points; but the limit of extreme violence is very strongly marked. The most characteristic of these storms commence near the equator in both hemispheres. In the Atlantic they are confined to the Northern hemisphere, in the Indian to the Southern. In the Pacific they occur in the China seas only. They are always accompanied by great disturbance in the electric and magnetic state of the earth.

Cyclonic storms exhibit many peculiarities. In the West Indies they commence not far from the north-eastern extremity of South America. The storm travels westwards through the West Indian islands, and then turns to the north-east, near the coast of North America, dying away generally in the latitude of New York. The direction of the wind in the storm is continually changing. In the Northern hemisphere it moves always from north by west to south, and then by the east to the north again. The actual storm, therefore, moves in a spiral or corkscrew shape. The width of the storm is not often so much as 500 miles, and the total distance travelled seldom more than 5,000 miles. It is often much less. In the Southern hemisphere the storm travels westwards, as in the northern seas, but the direction of the wind in the storm there varies from north by east to south, and thence by the west to north. In the centre of such storms the mischief done is generally very great, and the disturbance is extreme. The usual, though not the only, period of these storms is from July to October in the Northern, and from January to April in the Southern hemi-

spheres. In the Indian Ocean the change of the monsoons is the period of storm.

The cyclonic storms of the Tropics are repeated, though on a much smaller scale, in various parts of Europe, and on our own shores. They are easily detected by their spiral nature, by the constant shifting of the wind during the storm—always in the direction stated above—and by the great magnetic disturbances preceding and accompanying them. They have, however, no well-defined path repeated from time to time with little change; they are very much narrower in the breadth of country affected, and they have no well-defined centre. In the case of the great hurricanes, there appears to be a partial vacuum in the axis of the storm; and here most of the serious mischief to houses, ships, and other obstacles seems to take place.

The *simoom* is a burning wind blowing with considerable violence, and accompanied by a peculiarly oppressive sensation. The *scirocco* is a hot wind from Africa, on the coast of the Mediterranean. The *föhn* is also a hot wind, blowing over Switzerland from time to time. All these are results of the intense heating of the air in the interior of Africa, and they are of the nature of storm winds, but they are very different from cyclones and other spiral storms.

We must now return to the vapour atmosphere, and the mode in which it acts. In the ordinary state of the air on a fine day with little cloud, there is a certain quantity of vapour present in the air, not interfering with its clearness or transparency, and not recognized by the senses. After sunset, the air continuing clear, the earth cools by radiation, and leaves and other objects near the earth radiating

heat also, become much reduced in temperature. At a certain point of cooling, the vapour near them is converted into water and deposited as dew. If the temperature is reduced in this way below the freezing point of water, which may easily happen with a very clear air, even in hot climates, there will be a deposit of hoar-frost. All this time the temperature a few feet above the earth is very little lowered. Six feet above the grass the chilling is only one-twentieth of that on the grass itself. If the sky is obscured by cloud or mist, the radiation is checked, and no dew is deposited. Autumn is the season of heaviest dew.

Aqueous vapour is frequently rendered visible as mist, fog, or cloud. These are varieties of the same condition. Mist is formed when currents of air of different temperature, both containing invisible vapour, meet near the earth. In valleys such mixtures are very frequent, and in mountainous countries very striking. Fogs are formed in the same way in temperate climates at various seasons, and hang over shores and the mouths of certain streams.

Clouds are produced when mixtures of currents take place at some distance above the ground, and the visible vapour is entirely detached from the earth. There are several varieties of clouds, some floating at a height of many miles, some hovering in large masses in mid-air, some drooping downwards and almost touching the earth. They are rarely alike long together. They assume, as we know, the most fantastic shapes, and are occasionally decorated with brilliant tints of colour. It is only the clouds that form in large masses and approach the earth that dissolve into heavy and long-continued rain, but all clouds are capable of yielding rain, and drops some-

times, though rarely, fall through air perfectly clear and cloudless.

Rain is the final result of the changes that take place in the vapour atmosphere, when, by alterations of its electrical state, accompanied or caused by opposing currents of air at different temperatures, it has been rendered visible. That water should be lifted into, and form part of, the atmosphere, should be drifted through the air for hundreds or thousands of miles, should be converted into visible cloud, and then should fall to the earth as rain, is one of the most marvellous, as it is one of the most essential, of the natural conditions that render our globe habitable. This circulation of water is an event of every day. Wherever there is a large expanse of water, there is evaporation from it. Whenever the air becomes loaded with moisture, and is drifted along in currents, it must in time meet other currents in a different state, and whenever there are opposing currents, it is likely that there will be changes in electrical condition, which will end in setting free water from the clouds. Over the ocean everywhere, and over a great part of the land, the lower currents of the air travelling towards the equator cool, and, therefore, holding only a little water, are constantly being heated and saturated. This same air, when saturated, rises and passes back again towards the poles, passing into colder countries, mixing with cooler currents, and forming mist and cloud, or falling to the earth as rain.

Rain is distributed over the earth with a certain amount of regularity, and is especially abundant within the Tropics. Where the sun is vertical the earth is intensely heated, and the air is generally

calm. The air is then like a vapour-bath. As it ascends and is chilled, clouds are formed, and as soon as they are formed, torrents of rain descend. There is in tropical countries a rainy season, when all the rain of the year falls. The quantity is enormous, varying greatly in different places. In one place in India it amounts on an average to about 600 inches, or 50 feet in a year. The rain that falls in many places in the temperate climates of Western Europe is not more than a thirtieth part. All this vast quantity of water falls in the space of three months, the rest of the year being dry. As much as 30 inches of rain are recorded to have fallen in one day in some parts of India. This is more than falls in a whole year in most parts of England.

Where there is no rainy season, the quantity of rain is smaller, and it is spread over a much larger number of days. This is the case in the region of variable winds already alluded to, and generally in temperate latitudes. The average rainfall is, however, little guide to the real peculiarities of any station, even where the climate is most equable, and the quantity, as well as distribution of rain, are very greatly dependent on local causes. Among these the form of the land and its distance from the sea, the position of the nearest high ground, the nature of the nearest marine currents, and other facts in Physical Geography are exceedingly important. The total amount of rain falling on an average every year in temperate climates near the sea amounts, in few places, to so much as 50 inches; but on hill and mountain sides it is often very much greater, especially when the hills rise rapidly on the extremity of a continent, and most especially when the coast

looks towards the west, the prevalent winds being then from the ocean. There is in these cases more rain on the coast than inland. Thus, on the east of England, the average is in many places not more than 20 inches, while, on the west coast, it is often upwards of 30, and on the west and south of Ireland, nearly 40 inches. In the middle of England about 25 inches is the average. On the hills in Cumberland and Wales, however, especially the former, the rainfall is not only much heavier generally, but in particular spots it is enormous. At Seathwaite it is 120 inches. While so much rain is falling on these hills near the coast, the country to the east is particularly dry, the rainfall often not exceeding 21 inches. As a striking example, we may point out that at Liverpool, the sea-level, the rainfall is $24\frac{1}{4}$ inches; on the Lancashire moors adjacent, 45; and at Durham only 17 inches.

It is evident from these facts, not only that the rainfall depends on many causes, but that it is easy enough to discern what many of them are. Islands have a heavier rainfall than continents; hills receive more rain than the coast; the slopes of hills and mountains looking towards the prevalent winds, when those winds blow over water, receive more rain than the opposite slopes. These are all evident facts. In the interior of continents the conditions are not so easily recognized, but they exist. Where there are great mountain chains, the winds coming from the sea, loaded with moisture, are chilled, and obliged to discharge their moisture before they reach the top of the mountain range. Thus the Andes completely cut off the rain supply from the Atlantic, and force the whole back to the Atlantic basin.

This is caused by the prevalent winds which blow from the east over the Atlantic and Gulf of Mexico, or cross the comparatively low flat plains of South America, but which are chilled and deprived of their moisture by the lofty mountain wall running down from pole to pole. On the other side of the Andes is a district in which for the most part no rain falls, and this is because the winds hardly ever blow from the Pacific towards the coast of America. Near the central part of the great mass of land in the Eastern hemisphere there is a vast tract in which also scarcely any rain falls. To the south of this rainless district of the Old World, round the whole of the intertropical part of the Indian Ocean, is a district of extreme rain, which includes the north of Australia and the large islands of the Indian Archipelago, as well as the east coast of Africa within the Tropics. In many places in this district the average approaches 100 inches per annum, falling within a few months. In the corresponding latitudes in South America the fall is even heavier, much exceeding 100 inches. The coasts of Brazil and Dutch Guiana are the wettest. In Africa there is also an extreme rainfall on the shores of the Gulf of Guinea.

The Southern hemisphere is sometimes regarded as the water reservoir, and the Northern hemisphere the condenser of the earth. It has been estimated that nearly fifty thousand billions of gallons of water (50,000,000,000,000,000) annually reach the earth from the clouds, and that of this quantity less than one-half runs back over the surface, conveyed by streams and rivers to the sea. Of the rest a large proportion is at once re-absorbed into the air, while

the remainder enters the earth and is lost sight of for a time to reappear in springs. Evaporation is constantly taking place from all parts of the surface, but especially from the warm oceans, to supply this vast quantity of moving fluid.

Snow is a form assumed by solid water in the higher parts of the atmosphere by the condensation of vapour in a tolerably calm atmosphere. It is beautifully crystallized in six-sided stars, which offer so much resistance to the air that they are a long time falling, even in calm weather. During wind they often collect into small pellets, which are hard, and are drifted far by the wind. Snow is formed at great elevations, even in the warmest part of the earth, and there is a limit of height in all great mountain chains above which water only exists in the solid state. This is called the snow-line. It varies greatly on the two flanks of a mountain chain, and even on the same side in different years. In the Andes within the Tropics it does not much exceed 18,000 feet. In the Himalaya (north of the Tropics) the snow-line is at 20,000 feet on the north side, and but 18,000 feet on the south. In the Alps it is between 8,000 and 9,000 feet; in Norway less than 4,000 feet; and on the shores of the Arctic Sea 2,000 feet. In all these countries the water that falls above the snow-line falls in the solid state, and remains heaped. Rain never falls. Evaporation takes place from the snow, but except where it sinks down into sheltered valleys in large quantities, which accumulate more rapidly than the snow melts, there is little apparent change from year to year.

The accumulation of snow in a valley at a depth

below that of the snow-line becomes, under ordinary circumstances, a glacier. The lower snow is squeezed and hardened into grains by the weight above it, and is converted into a kind of ice. Each fresh fall of snow is changed in time in the same way, and forms a fresh layer of ice; and in time the tongue of ice thus formed passes down to a great distance, is cracked, broken, and re-cemented as it travels onwards, and receives on and amongst its mass vast quantities of sand, earth, gravel, and fragments of rock, that have been removed by the action of weather from the country above. Provided there be a ravine or convenient gulley down which the snow can move gradually, and which enjoys tolerable shade from the sun and wind, the glacier will continue to extend for many miles, and till the melting at the foot each summer balances the advance made during the year. Some glaciers are of very large dimensions. In Switzerland there is one more than sixteen miles long; in the Himalaya Mountains there is one sixty-four miles long. Many great rivers take their rise at the foot of glaciers. In Europe, the Rhine and Rhone; in Asia, the Indus and Ganges are thus circumstanced.

Hail is another result of change in the aqueous vapour present in the atmosphere. Unlike snow, it generally forms and falls to the ground in hot weather, and sometimes in very warm climates. It rarely falls except during storms, and when there is great electric disturbance. Hailstones generally have a nucleus of snow, and are coated with ice frozen upon this nucleus as it descends through the air. Hailstones thus formed frequently come in contact in the air, and are frozen together, forming

occasionally blocks of ice large enough to do serious mischief in falling.

The weather is a term used to express the condition of the atmosphere at any special time in a certain place. It refers to the temperature, the moisture or dryness of the air, the pressure of the air, the clearness of the air, the state of the sky, whether clear or cloudy, the movement of the air, and many other conditions constantly altering. Fine weather means a clear sky, dry air, moderate temperature, and a high barometer. Bad weather the contrary. When fine weather prevails during a large part of a season, it is said to be a fine season; while a place where the weather is more generally fine than bad is said to enjoy a fine climate. Climate and weather, though complicated enough, and dependent on many conditions, are matters about which so much is thought, said, and written, that we all have certain ideas in reference to their meaning. Climate, however, depends so much on the state of the air that we cannot conclude our account of the atmosphere without reference to it, while weather is but the climate as it exhibits itself at some special moment.

Climate depends on (1) latitude, which determines the mode in which the sun's rays fall, and the length of day and night at different seasons; (2) position with reference to the sea and marine currents and elevation above the sea; (3) circumstances of adjacent land. These act in modifying the quantity of heat and light, in determining the clearness of the air, the amount and distribution of rain, the liability to winds and storms, the humidity of the air, and its electrical state.

The quantity of heat received on any spot is expressed by the average height of the thermometer during the whole year. This varies for every station; but it is not impossible to connect by lines drawn on a map the places that are alike in this respect. Such lines are called *isothermals*. The mean temperature of the earth is estimated at $58\frac{1}{4}^{\circ}$ Fah.; but the Northern hemisphere is calculated to be, on an average, $3\frac{1}{2}$ degrees warmer than the Southern. This is caused by the excess of land in this hemisphere, and its extent near the equator.

Besides the mean temperature of the year, the mean summer and winter temperature are often needed. These are obtained and expressed in the same way, but the lines are very different. They are called *isothermal* and *isochimenal* lines respectively.

The range of temperature also varies very much. The mean daily range is the average difference between the highest and lowest points of the thermometer during the twenty-four hours. The mean monthly and annual range are calculated in the same manner. At Greenwich, the mean daily range is 16° Fah. It will be evident that places where the range is small must enjoy a more equable climate than those where it is great.

The length of day during summer is an important element of climate. In extreme north and south latitudes the sun remains above the horizon so long during summer, that the earth becomes greatly heated, and the heat is extreme. During winter the long absence of the sun produces extreme cold. In moderately high latitudes the summer heat and winter cold are greatest in the interior of continents, where the atmosphere is generally clear.

The position of a station with reference to the sea includes several matters. Height above the sea is one, and on it much depends. The temperature of the air diminishes as we rise above the level of the ocean, not indeed at any regular rate, but still with great certainty. In many places, where the ascent from the sea is rapid, the difference is at the rate of 1° Fah. for every 200 or 300 feet. Thus at considerable altitudes a very marked difference of climate is observed between places on the coast, and those on a mountain side, or on an elevated plain, in the same latitude.

The nearness of the sea affects climate to a considerable extent. The sea is much slower in undergoing change of temperature than the land, and the temperature of a great body of water is very equable. Islands and the countries near the sea thus enjoy a more moderate and equable climate than the interior of continents. This is still more observable when marine currents bring warm water along a shore, as is the case with the Gulf Stream on the European coast. This alone makes a difference in climate equivalent to many degrees of temperature. Thus, the mean annual temperature of the north of Ireland, in Latitude 55° N. is about the same as that of New York, in Latitude 42° . But owing to the Gulf Stream, the climate of Ireland is far more equable than that of the American shore, as well as having the same annual temperature, although 13 degrees nearer the equator.

Mountains near a coast separating a station from the sea, or mountains in the vicinity of an inland station, produce an enormous influence on climate. The plains near the Alps in the middle of Europe

have a totally different climate from the low lands beyond to the north and south. In proportion as any place is near or far from the sea or a large sheet of water, so will the climate be more or less equable. The vicinity of mountains or high plateaux deranges a climate and renders it extreme. The vicinity of large tracts of water equalizes climate.

Very much of climate depends on prevalent winds. The prevalent winds of Europe, proceeding from the west and south-west, and passing over a large extent of sea warmed by marine currents, the climates of western Europe and England are very much warmer than those of corresponding latitudes on the opposite shores of America. This has been alluded to already, but is too important not to be repeated in this place. The west winds of America are land winds, while those of Europe come from the sea. The latter are warm and moist; the former hot in summer and cold in winter, but generally dry. The same peculiarities are noticeable elsewhere.

It will be seen that climate depends much more on other causes than on latitude, and that these other causes are by no means incapable of change. In the course of time such changes take place on the globe; and thus climates may alter, and with them the animals and vegetables that dwell on the earth, and that must adapt themselves to the existing state of the surface. It is quite possible for the Gulf Stream, by certain changes of level of part of North America, to change its course, and run through the valley of the Mississippi into the Arctic Ocean. It is possible for land to rise in the Atlantic and sink in Europe, so that the island we inhabit might have an easterly instead of a westerly ocean. The result of such

changes would be a climate totally different and much less temperate. The existing races of vegetables and animals must be replaced by others, and men would cease to inhabit in large numbers such inhospitable shores. These possible results must be borne in mind in considering the influence of position on climate.

CHAPTER VII.

EARTHQUAKES AND VOLCANOES.

THE surface of the earth is not always in repose. Besides the changes that are known to take place constantly by the action of water and by the weather, removing and paring away the land in some places and depositing it in others, some large districts are subject occasionally to sudden convulsions, accompanied by cracks in the surface, destroying houses, and even towns. Such disturbances are called *earthquakes*. They are produced by explosions deep in the interior of the earth, taking place probably in large cavities. These explosions, which may be the result of water entering the cavities where the temperature is very high and the rocks exist in a molten state, produce undulations or waves of the earth's crust. When the explosive force is not sufficient to break asunder the solid rock above, the earthquake will be repeated from time to time, till a vent is formed. When a crack is made there occurs an eruption of steam, ashes, stones, and gases, which forms in time the conical mound, increasing sometimes to a mountain many thousand feet high, called a *volcano*; and after a volcano has erupted, serious earthquakes in its neighbourhood no longer occur.

Such are earthquakes and volcanoes. They are among the grandest and most impressive of all the appearances of nature. Happening only occasionally, and in very limited districts, most of which are far

removed from civilization, they are events that only come within the experience of a few ; and they are the more terrible from their rarity and unfamiliarity.

All earthquakes, however, are not great or mischievous disturbances ; nor are all directly connected with volcanoes. There are small vibrations bearing the same name, and due to similar causes, affecting most parts of Europe, and even our own island, and probably almost the whole surface of the earth. These are tolerably frequent. There are accounts on record of more than a hundred earthquakes felt during the first half of the present century in various parts of the British islands ; this being equivalent to one every six months. None of them have done damage or injured human life ; very few, indeed, being sufficient to have attracted much attention, except as curiosities. In other parts of Europe there have been similar movements. In the countries near volcanoes, some of these have been very serious. Elsewhere, with few exceptions, they have simply alarmed, without injuring. On the whole there are accounts of about 1,600 earthquakes in Europe in the first half of this century, being at the rate of thirty-two in each year, or one every eleven days.

Great earthquakes are very destructive and terrible occurrences. They are common in certain parts of the West Indies and South America ; but there have also been examples of extreme disturbance in Sicily, near the volcanic mountain of Etna, in Italy ; others near Vesuvius, and others in Asia Minor. A very terrible earthquake occurred more than a century ago (in 1755) near Lisbon, when the town was

nearly destroyed, and 60,000 persons perished; but this was probably connected with some submarine eruption in the bed of the Atlantic. The circumstances attending such disturbances are in the highest degree appalling. Not long ago an earthquake occurred in the plains on the eastern side of the Andes, in South America, by which the whole city of Mendoza was destroyed, and almost all the population perished.

These convulsions of the earth are often preceded or accompanied by rolling sounds, explosions, and other noises; by a peculiar state of the air; and by disturbances in its electric condition. Noises not unlike thunder have been heard at the same time in places some hundred miles asunder. The earth is lifted up, sinks down, and even twists round, producing results so extraordinary that they seem impossible. There are three kinds of motion felt, the most simple being a mere undulation; the next, a sudden explosion or sharp heave, without undulation; the third is mixed, and involves motion onwards as well as upheaval. It is this latter, the rarest of the three, that produces the peculiar twisting motion alluded to.

Earthquakes vary greatly in the extent of surface acted upon. Some are limited to a few acres, others affect nearly half the land on the globe. Those occurring in England are of the former, that of Lisbon of the latter kind. They also vary very much in the time of their duration, some of the worst having been almost instantaneous, while some of those of small importance have continued for hours, and even days, to communicate a slight tremble.

The city of Concepcion, in Chili, was destroyed, in

1835, by a single overwhelming shock, preceded by a few tremulous movements. In less than six seconds the city was in ruins. The Lisbon earthquake was also a very rapid event. In 1857-58 there was a series of earthquakes in southern Italy, which affected the whole of the main land for a distance of 300 miles in a direct line, the whole area disturbed exceeding 3,000 square miles. A large number of towns and upwards of 20,000 human beings were destroyed, the greater part of the destruction being effected in a few seconds.

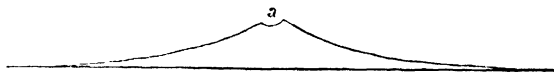
There are certain bands of earthquake disturbance on the earth. In some the shocks are comparatively weak, in others they are very strong. A moderately weak band extends from Iceland, including Ferro, Shetland, and the south-west coast of Norway to Christiania, perhaps reaching Greenland. A narrow but intense band stretches through Sicily and Italy into southern France and the north-east coast of Spain, and so northwards towards England by the Rhine. The most intense and remarkable of all is that of the chain of islands in the Indian Archipelago. Another band affects Western Australia; others of great intensity are recognized in South America. On the whole, these bands follow the direction of the lines of elevation which separate the great basins by which the ocean is broken up; they are very variable in length, breadth, and direction; they probably extend beneath the ocean; and earthquakes occasionally originate, and frequently extend, beyond their margins.

It has been suggested, as a conclusion obtained from observations, that the number of earthquakes occurring near new and full moon is greater than

the number occurring near the quarters, and that many more earthquakes occur during winter and autumn than during spring and summer. It has also been noticed for some centuries past that the number of severe earthquake shocks has been confined to two periods of the century, one a little after the middle and the other towards the end.

Earthquakes are, in many countries, almost certain signs of approaching volcanic eruption. The pent-up gases and steam explode and rend asunder the covering of rock, and open a passage from the interior of the earth to the surface. Whatever may be the general condition of the interior of the earth, it is certain that within all observed limits the temperature increases as we descend, and that wherever volcanic eruptions take place, there is a quantity of matter in a melted state not far from the surface.

FIG. 14.—SECTION THROUGH A VOLCANIC CONE.



A volcano is a hill or mountain of a sugar-loaf shape, formed or forming by the thrusting out from a crack in the earth of large quantities of rock, partly in a liquid state, like melted glass, partly in the state of fine powder, formed by the bursting of innumerable bubbles of gas and steam formed within the boiling rock, and partly of solid stones and fragments of cooled lava thrown up during the eruption. Some volcanoes are very small and mere hills, others among the loftiest mountains in great mountain chains, but the conditions are the same. At the top of

the hill or mountain there is generally a cup-shaped depression, called the crater (*a* in the above cut), through which jets of steam rise, and from which an eruption has taken place. Not unfrequently melted rock forces its way out, in a thick sluggish stream, through a crack made in the side of the hill. With the ashes and stones and fluid rock, which is called lava, there rise many gases, of which carbonic acid, nitrogen, and hydrogen are the principal. These are accompanied by chlorine and sulphur in considerable quantities. Vapour of water is always abundant.

The magnitude of volcanic eruptions is sometimes very great. The largest active crater known is in the island of Hawaii, or Owyhee. The volcanoes on that island are three, but all belong to the same mass of ashes, scoria, and lava, which extends 100 miles in one direction and 80 miles in another. The principal cones are nearly 14,000 feet high. The principal crater measures more than two miles across, and the depression that forms the crater, though constantly changing in depth, approaches 1,000 feet. Within this crater or cup is a lake of boiling lava, 500 yards across, which is the throat or gullet communicating with the interior. Sometimes the lava rises and fills the crater to a depth of some hundred feet, but more frequently the melted rock breaks out at the side. A few years ago it began to flow ten miles below the top, and the stream ran sixty miles, with an average breadth of three miles, and a thickness of from 300 to 600 feet. The eruptions from the Hawaiian group of volcanoes are remarkable for being accompanied by steam and ashes. The great eruptions of other volcanoes have been always described as abounding in both these products.

In an ordinary volcanic eruption the dense volumes of steam, that almost always burst forth at the commencement carry up vast quantities of fine light ash, which rise to a great height, far above the lower currents of air and into the clouds, very many thousand feet above the sea. Drifted by the currents at different elevations, the ashes are carried in every direction to vast distances. It is recorded that in the eruption of Coseguina, in the Andes, in 1835, the air was so darkened by the thick clouds of ashes, even at places fifty miles from the volcano, that people could not recognize each other, and the fowls went to roost. This lasted for forty-eight hours. The dust was carried in the direction of the wind at the surface about 700 miles in four days. In the opposite direction the upper currents conveyed the ashes 1,200 miles, and at this distance a ship sailed forty miles through the floating ash. All this material consists of the powder derived from the bubbles or froth of the boiling rock, through which the steam rushes during an eruption. With the dust large quantities of scoriæ, or light frothy scum of the lava, and even fragments of rock, are thrown up. Some of the latter are of several tons weight, and are thrown many miles from the crater. Similar fragments, though of much smaller size, can be seen at the foot of the crater of Vesuvius, and other active volcanoes.

Torrents of melted rock, or lava, generally burst out, either from the crater or from the side of the mountain, very soon after the commencement of an eruption. The lava is thrown out in jets, which rapidly cool at the surface, but remain melted at a small depth. The result is a pasty current of many miles in length, advancing slowly towards the lower

ground or the sea. In a single short eruption 100,000,000,000 of tons of lava have been thrown out in a few weeks.

After the lava has been poured out, the character of the eruption changes a little. The proportion of carbonic acid gas increases, replacing the hydrogen and nitrogen, which are among the first products. The quantity of vapour diminishes. Sulphur and a rich variety of salts are deposited, and various other salts, more or less soluble, and often richly coloured, including alum, are formed at the surface. These are often washed away by rain, but are almost immediately re-crystallized. They give a most brilliant and picturesque appearance to the walls of the crater and the numerous fissures in the lava.

When volcanic action is decaying, there still remain many very striking phenomena. Among them fumeroles of hot air, with steam and sulphur fumes, are very common. Carbonic acid gas is largely thrown out from these crevices.

Springs of boiling water are also occasionally seen, and they are generally, but not always, directly connected with volcanoes. Those of Iceland, called the *geysers*, are the best known. They are twenty-three miles from the great volcano of Hecla. The water rises at irregular intervals through a smooth pipe of flint, formed by deposits from the water, and into a basin also of flint, formed in the same way. A large column of water is thrown upwards of ninety feet into the air, and falls back into the basin.

Jets of mud, either hot or cold, also occasionally appear near volcanoes. They are called mud volcanoes, and are met with in places where formerly there may have been craters, but where now little

else remains to mark this condition. The mud issues with petroleum floating on it, and the water is often salt and sulphurous. The mud forms small conical hills, which sometimes extend over a considerable area.

Volcanoes are comparatively rare; and of active volcanic cones there does not appear to have been at any time a very large number at once on the earth. Four hundred would appear to exceed the total number of principal active cones at present recognized over the whole surface. Some of these no doubt include an area over which there may from time to time be many different points of eruption, for eruptions rarely succeed each other from the same vent; but when the mode of distribution of these four hundred is considered, it will be found that there are very large tracts of the earth in which there is no such communication from the interior to the exterior as is indicated by a volcano.

With comparatively few exceptions, the volcanoes are found on the rims or borders of the various basins which enclose the great oceans. If we consider them as partly in lines and partly in circular groups, we shall find that all the circular groups are in the ocean, and far from continents, while the lines are ranged round the edges of the oceanic basins. The most active is that of the islands of the Indian Archipelago, between the Indian Ocean and the China Sea. Next in importance is the Mexican group, between the two Americas, extending southwards into the high Andes along the west coast of South America, and northwards to the Rocky Mountains. The Mediterranean band, including not only Etna and Vesuvius, but the volcano of Santorin,

reaching Asia Minor and the Red Sea on the one side, and the Azores and Canary Islands on the other, is exceedingly well marked. In the interior of Asia, extending to China, is a volcanic district, little known, but very remarkable. Eastern Africa contains some volcanoes of importance. In the North Atlantic is a group near the Arctic circle, of which Hecla in Iceland is the centre. In the Antarctic circle there are at least three active volcanoes of considerable magnitude. New Zealand contains an active volcano.

The best known among the active volcanoes are as follow:—1, those of South Italy and Sicily (including Etna, Vesuvius, and Stromboli); 2, those of the Greek Islands, of which Santorin has been very recently in an active state; 3, Hecla, in Iceland; 4, the Central American group; 5, the South American group, including Cotopaxi and Chimborazo, under the equator, and those of the Peruvian and Chilian Andes, further south; 6, the Java group; 7, the groups in the Pacific Ocean, of which Hawaii, in the Sandwich Islands, is by far the most important.

They are not mentioned in order of chief energy and magnitude, as the Asiatic and American groups are the most intense in their action, but rather as they are known from description and easily reached and visited from England. Many of the great volcanoes are almost inaccessible. The following short notice of the history of some of the European volcanoes will be useful. We begin with the South Italian, as the most familiar. They include a large district.

The whole of Italy, from the valley of the Po

southwards, shows marks of comparatively recent volcanic disturbance. Near Parma and Modena there are mud volcanoes. Near Rome are cones and craters that have been in eruption at no distant period. Near Naples is Mount Vesuvius, still active, and close by it is a multitude of cones and craters, some of which have erupted within the last thousand years, and others not long before. Between Naples and Sicily are the Lipari Islands, among which is Stromboli, constantly burning; and in Sicily is Mount Etna, a noble conical mountain, entirely volcanic, and nearly 12,000 feet high, where the material erupted covers at least 600 square miles. Between Sicily and Africa is a shoal, where a few years ago an island rose out of the ocean. Thus the great belt of volcanic energy, of which Etna, Vesuvius, and Stromboli are the active vents, is at least 700 miles in length. Some parts of it have been in eruption for a very long time, and it is almost certain that all great volcanic bands may be considered permanent so far as the human race is concerned. Etna has been an active volcano ever since human records have existed, the first disturbance of which we hear being nearly 2,500 years ago. With intervals of repose—sometimes of one or two, sometimes of eight centuries—there has been a succession of eruptions, accompanied by earthquakes, many of them of the grandest and most destructive nature. Vast floods of lava have frequently issued, sometimes running more than twenty miles, and a mile or two in width. Even so lately as in 1865 the great crater and a portion of the side of the mountain was split asunder, and a number of new cones and craters were formed. On this occasion

lava on a large scale was poured out, and all the phenomena of a great eruption are still traceable. There are small eruptions and jets of steam and gas from the principal crater very long after the termination of the great disturbance. On the side of Etna there are upwards of a hundred cones and craters, some of them several hundred feet high.

Stromboli is one of a group of volcanic islands in the sea between Sicily and Naples. It is more than 2,000 feet high, and rises directly from the sea, being entirely composed of lava and volcanic ash. It is always smoking, the smoke consisting of steam and some gases. No important eruptions are recorded.

Vesuvius, although a long distance from Etna, appears to be connected with it underground, as the two volcanoes are never active together. It is an isolated hill, rising about 4,000 feet above the sea; but the volcanic district, of which it is the present vent, extends about 40 miles, to Ischia, with a breadth of 20 miles. The whole of the hill and the country adjacent seems to consist of erupted matter.

The first eruption recorded of Vesuvius took place about 1,800 years ago. With intervals of one, two, or three centuries of repose, and sometimes less, it has since been active, and during this century there have been several eruptions of considerable though not extreme magnitude. The only vents at present are on or very near the principal cone and crater; but two hundred years ago eruptions took place from cones many miles to the west. The last considerable eruption previous to one still going on was in 1861, when eleven small new cones were formed, and a long fissure produced in the ground. The eruption of 1867-8 has been important, though less so than many

recorded. The addition to the mass of the mountain by these later eruptions has not been large. Great care has been taken in the examination of the phenomena, and the quantity of matter erupted on each occasion has been estimated.

The singular group of islands in the Greek Archipelago, of which Santorin is the largest, is a circular chain of islands, consisting of an extinct crater, whose rim projects from the sea; and in the centre are two or three small islands, which are the result of successive eruptions in the interior of this vast crater. One such eruption took place about a century ago, and formed an island. This island has been more than doubled during an eruption that commenced at the beginning of 1866, and has not, after two years, ceased to pour out melted rock, which rises from a great depth below the level of the sea.

Hecla is one of the chief of the European volcanoes. It is about 6,000 feet above the sea, and rises in the south of Iceland. It has erupted on an average about eight times in a century during the last thousand years. The volcanic district is a region of about 3,000 square miles, so wild that it has been hardly possible to penetrate it. Besides Hecla there are many other considerable volcanoes, and the whole island is more or less volcanic. There are single streams of lava 50 miles long and 15 miles broad.

The South American volcanoes are remarkable for the extreme magnitude of the eruptions, corresponding to the great height above the sea at which they take place. There are two principal groups, one of twelve, the other of seventeen active volcanoes, and some of the cones are more than 20,000 feet above the sea. There is another group, large in number of cones,

but less elevated, the average being 13,000 feet. From some of the loftier craters a jet of steam and gas is thrown up 3,000 feet above the edge of the crater, and from them sounds issue and ashes have been ejected that have been recognized by the mariner, and have rendered the air obscure, at distances of more than a thousand miles.

The great volcanoes of the Indian Archipelago are scarcely less remarkable than those of South America. They also send out vast showers of ashes; they are accompanied by fearful earthquakes, and floods of lava issue from them.

The existing and active volcanoes of the earth are accompanied by cones and craters now entirely at rest. Some of these may be of great antiquity, but if they are near a present seat of action we cannot regard them as extinct. There are, however, in other parts of the earth, at a great distance from volcanic bands, very clear proofs that there were once outbursts of steam, gas, ashes, and stones, with floods of melted rock of precisely similar character. In France and Germany are extinct volcanic districts that exhibit all the ordinary phenomena. Other countries also contain them. Thus we may safely conclude that at various times in the earth's history there has been this kind of communication between the interior and the surface of the earth, and that these communications are limited to certain districts which are not of great extent, and which are shifted very slowly.

It is important to observe that while the vicinity of the sea, or at least of water, seems essential, the neighbourhood of a lofty mountain chain is by no means important to the existence of an active volcano.

Volcanoes seem to have relation to lines of eleva-

tion, and are doubtless indications of the points where elevatory force acting from below is likely to show itself. They are also connected with certain parts of the earth's surface where the strata have been disturbed, and other large districts where there are slow movements of upheaval and depression. But there are no lines of volcanic action that can be distinctly traced to have relation to the great lines of upheaval easily seen and recognized on a map or the globe.

CHAPTER VIII.

DISTRIBUTION OF PLANTS AND ANIMALS.

OUR earth is so contrived, its surface so consists of an alternation of land and sea, the whole surface is so covered with a veil of air, and the conditions of temperature are such, that there is a place in almost every part of land, water, and air for some form of life. Whatever the nature of life may be, of this fact there is no doubt. Vegetation thrusts itself everywhere, and animal life is always at hand. The barren and massive granite soon serves as a convenient place on which a lichen can grow. The pool of dirty water is almost immediately crowded with animalcules. The very atmosphere is alive with insects and birds. It is a law of nature that nothing should be lost, and, however it is caused, there is no doubt that life is present everywhere, adapting itself to the existing conditions.

Vegetation in its simplest form would seem to be produced by a very small but peculiar chemical change acting on inorganic matter. The structure becoming more complex, we find plants more and more limited in their range and distribution; but in every case life belongs to matter, it is constantly undergoing change, and it is always present. The simplest forms are those which are most widely spread.

A little consideration will show that life is in

a certain sense capricious. Certain conditions are favourable for some kinds of development, while other conditions are preferred for other kinds. Climate is strongly marked by vegetation, and altogether influences it. But although similarity of climate produces similar vegetation at all times, it does not repeat the same species, either at different times or in different places. Thus, in distant parts of the world, where the climate is so nearly identical that the same plants will flourish, and similar profitable crops can be obtained from the same seed, the natural growth is different. Each country has its own group; and this natural group, which is called, in natural history, its *flora*, appears to be the result of the changes produced by climate, these being the natural influences affecting plants.

The distribution of plants may be considered either with reference to places nearly at the same level, but differing in latitude, or to those in the same latitude but at different heights above the sea. Thus, within the Tropics, on the shore of the Gulf of Mexico, there is a certain natural vegetation. Advancing northwards, along the shores of North America, from the torrid to the frigid zone, there is a constant succession of new plants and trees, the old ones disappearing. From palms we come to forest trees, and from them to pines. At length trees disappear. In the same way, in ascending the Andes from the coast, a similar change would be observable. As we ascend we lose the tropical character; passing through the sub-tropical to the temperate, and thence to the frigid, in something of the same manner.

In a very general way the following will express

the characteristic vegetation of different zones or belts of country differently situated:—

1. Near the equator (within 15° to 20°) palms and bananas are the most abundant trees, from the sea-level to a height of 2,000 feet. The food-plants are banana, nuts and shoots of the palm-tree, bread-fruit-tree, pine-apple, tamarind, sugar-cane, yams, cocoa, and spices.

2. Beyond this, for another ten degrees in the Northern, but much farther in the Southern hemisphere, tree ferns abound, and species of fig are very numerous. These range from 2,000 to 4,000 feet in height at the equator. Maize and the sweet potato are added to the food-plants, some of the tropical kinds becoming rare or disappearing. Coffee is common.

3. Myrtles and laurels, rice, cotton, and tobacco, characterize the next or sub-tropical regions. They extend from 4,000 to 6,000 feet above the sea at the equator, and are accompanied by a rich variety of fruits, and some palms. They extend into some of the southern States of North America, and touch the shores of the Mediterranean in Europe and Asia Minor. In Asia they extend from the mountain chain to the Tropics, and on the east coast into China and Japan. In South America, east of the Andes, they are met with as far as Brazil. Wheat is cultivated as well as maize among corn foods. Orange and lemon trees are common.

4. Evergreen trees belong to the warm temperate zone. These range generally as far as 40° in the Northern and 35° in the Southern hemisphere. The vegetation is totally different in the two hemispheres, but the products of each may, by careful manage-

ment, be cultivated in the other. The height above the sea-level at the equator corresponding to this form of vegetation is from 6,000 to 8,000 feet. The food-plants in this region are wheat, barley, potato, millet, chestnut, the vine, and many common fruits. The heaths are here common plants in the warm temperate zone in both hemispheres.

5. Deciduous trees—those whose leaves fall during autumn, leaving the tree bare in winter. These belong chiefly to the colder temperate zone, and correspond to a height of from 8,000 to 10,000 feet at the equator. Of this zone the oak, the beech, the ash, the elm, the horse-chestnut, the walnut, the lime, and many pines are the natural inhabitants. Wheat, barley, oats, and potatoes, and the plum, apple, pear, cherry, and other hardy English food-plants are cultivated in the Northern hemisphere. In the Southern there are none of these, and no fruits corresponding to them, but most of them may be grown if introduced.

6. The region of pines, or the sub-Arctic zone, corresponding to a height of from 10,000 to 12,000 feet at the equator, comes next. Here the cultivation of wheat ceases, and is replaced by oats and rye. The willow, alder, birch, juniper, larch, and Scotch fir are the common trees; the strawberry, raspberry, cranberry, bilberry, &c., are the products of stunted bushes. These all belong to the Northern hemisphere. In the Southern there are little more than mosses and corresponding species of birch and beech, but in the latitudes we are now describing there is little land, except Patagonia and Tierra del Fuego, a great part of which is lofty.

7. The rhododendron region belongs rather to high elevations or mountains, especially the Hima-

layan chain and the Alps, and is poorly represented in the Arctic zone, and hardly at all in the Antarctic. Stunted pines and birch are sometimes seen. At the equator this region occurs from 12,000 to 14,000 feet above the sea.

8. The extreme region is that of lichens and mosses. These are Alpine plants, which thrust themselves in wherever life is possible, and sometimes prepare the way for a higher class of vegetation. The lichens and mosses are met with at extreme elevations and in extreme latitudes. Some are edible, serving as food to the few large quadrupeds and human tribes that inhabit such desolate regions. They extend, according to circumstances, to an elevation of nearly 16,000 feet, perhaps nearly 20,000 feet in some places, and towards the poles they reach beyond the point where snow always covers the land, being met with as a growth on the surface of the snow itself.

The limits here given are not absolute, and are liable to be overpassed in many ways by accident or human interference ; but they serve as a useful guide to the general extension of those plants and trees that are most familiar. They especially fail in the Southern hemisphere, where, the land being of small extent and detached, the various conditions of growth are different. The palms and tree ferns extend much farther southwards than they do northwards, and the gum trees and acacias, the aloe tribe, and many others, flourish in latitudes where the natural growth in the Northern hemisphere is so different as to offer a striking contrast. In all these cases it is easy to trace the cause of difference in the climate and conditions of existence.

In similar positions with regard to latitude, in cor-

responding positions of climate, and in places otherwise similarly circumstanced in the two hemispheres, the tendency to similarity of result may be discovered by a marked resemblance in the vegetation. Corresponding plants, or those which occupy a similar position in different countries, are called *representative*. This is the case whether the representation is on a small or large scale, and whether it is shown in form or internal structure. The strange succulent plants called *cactus*, among the most curious and grotesque that grow, are very abundant in a peculiar climate in South America. A whole tribe, called by botanists the *Euphorbiæ*, replace and represent them in similar latitudes in South Africa. There is a peculiar kind of gigantic pine, with prickly leaves, growing in Brazil, called the *Araucaria*, or sometimes the monkey-puzzle, from the difficulty the monkeys find to climb it. A very similar tree, but different in species, represents it in Norfolk Island, a detached island far away in the Pacific, near the eastern shores of Australia. A hundred such illustrations might easily be found. But representative species do not always prevent the plants belonging to one country from driving out those of the other when introduced. Thus the palm-tree that yields the cocoanut, is a native of the West Indies. It was long ago imported into India, and in Ceylon it has driven out many native species, and millions of cocoanuts are now exported annually from that island alone. The potato, imported from America a few centuries ago, is now one of the most common and useful of the food-plants of Europe. Wheat, on the other hand, introduced from Europe into North America, is now grown there to so great an extent as to supply

very largely the European demand. There would seem to be hardly any limit to this power of change, and to the adaptability of plants to new stations, although in a natural state they seem absolutely fixed, and the number of cases of migration which cannot be traced to human influence is few and unimportant.

Owing to the wide spread of the human family over the earth, and the tendency of man to carry with him and endeavour to cultivate the plants to which he is accustomed, owing also to the occasional conveyance of seeds, as of weeds and other common plants, by accidents, there is found to be a great mixture of plants in every country. This is greatly increased, because in many countries there has been a sensible change of climate within a comparatively short period, and in some cases a change of level, while there is evidence of some spots that are now islands having been formerly parts of continents. Thus the actual vegetation, especially in cultivated and long-settled countries, is exceedingly complicated, and differs greatly from that which belongs to the district by latitude, climate, and position. There are some few plants that seem to range naturally almost everywhere; but this is altogether the exception to an important general rule.

There is a distribution of marine vegetation of something of the same general nature as the vegetation on land. Eight marine provinces have been described by Dr. Hooker, and differences in depth correspond in some measure to differences in latitude and position. The provinces are: (1) Northern Ocean, with sea-weeds of very simple structure, living at almost all depths; (2) North Atlantic,

characterized by the *fucus*; (3) Mediterranean; (4) tropical Atlantic, with the Gulf weed; (5) Antarctic, with forests of tangled weed; (6) Australian; (7) Indian Ocean and Red Sea; (8) Japan and China seas. It will be seen that most of these are enclosed, or partly enclosed, seas, as the weed grows chiefly not far from shores. Many of the species are representative.

Animals are not less clearly arranged and distributed in natural groups confined to distinct regions than plants; but they have for the most part greater powers of migration, and certain tribes, particularly well provided in this way, are enabled to visit all heights, and range to almost all distances. Large classes of animals, however, are very little able to quit the region in which they are born, and if circumstances cease to be favourable to their existence, they cannot transport themselves to more convenient stations.

There is a very well-marked distinction between animals inhabiting water and those who dwell on land, and of these latter there are some who make the air their chief place of abode. Thus animals are divisible into three groups; but it is necessary that the student of Physical Geography should understand the general outline of scientific classification with regard to animals to know the full value of the groups existing in different districts. These are based on essential peculiarities of structure, and are as follows:—

All animals are either vertebrate or invertebrate; that is, they either possess or do not possess a backbone. Of those that do (*vertebrata*) there are four well-marked groups—mammals (which give suck to

their young), birds, reptiles, and fishes. The first class includes the ordinary quadrupeds and a few aquatic animals, as the whales. Man is at the head of this class; and monkeys, which are four-handed (*quadrumana*), come next. The *carnivores*, or flesh-eating mammals (lion, tiger, &c.); the *ruminants* (ox, sheep, camel, deer, &c.); and the *pachyderms*, or thick-skinned tribes (elephant, horse, pig), come next. The *rodents*, or gnawing mammals (beaver, hare, rat, &c.); the *edentates*, or toothless mammals (ant-eater, armadillo, sloth); the *cheiroptera*, or flying mammals (bats); the *marsupials*, or pouched mammals (kangaroo); and the *cetaceæ*, or whales, complete the list. Of birds there are six groups—birds of prey, climbers, warblers, poultry, and swimmers. Of reptiles there are frogs, serpents, lizards, and tortoises. The subdivisions of fishes are less important.

Of the invertebrates there are the *articulata* (insects, crustaceans and worms); *mollusca* (cuttle-fish, snails, oysters); *radiata* (star-fishes and coral animals); and *protozoa* (sponges and foraminifera). These are the chief divisions.

The group of animals inhabiting a district is called its *fauna*, and is generally composed of a considerable mixture, including some or most of the principal divisions. There are, however, many exceptions, some islands having had no quadruped when first discovered, others are without reptiles. Few districts are without birds, and perhaps none without representatives of most of the invertebrata. The vertebrates are called the higher, and the invertebrates the lower, as having more or less complicated organization. Of course many strictly aquatic faunas are without some of the natural groups; though

even this is not always the case, except with regard to birds, as there are marine quadrupeds or mammals (whales, seals, &c.), and marine reptiles (turtles).

As with plants so with animals—the natural fauna of a place is not always capable of holding its own against emigrants; and thus where man has had an opportunity of interfering, the present condition is a sort of compromise, and often a transitional state, in which the native tribes are dying out and strangers taking their places. Care must be taken to discover whether the apparent is the real fauna.

There is a great difference observable between the faunas of stations very similarly situated in regard to latitude and climate in the Eastern and Western hemispheres. There is an equal difference seen in comparing places in the north and south temperate zones. Even in islands removed a very moderate distance from a continent or from each other, there are sometimes entirely distinct faunas. Let us trace in what this difference consists.

The larger carnivora are chiefly confined to the Old World, and indeed to the eastern part of it. The lion, tiger, leopard, panther, and hyæna are represented in America only by the puma, the jaguar, and others of much smaller size. But there is a marked difference of species even between the larger quadrupeds of tropical Asia and Africa, and this difference is also seen in most of the other tribes. Thus of the pachyderms, Asia and Africa both have the elephant and rhinoceros, but the Indian and African kinds are totally different; Africa has the hippopotamus also. Asia yields the true horse, the ass, and several marked species of the same genus. Africa has the

zebra and some others, also quite distinct. Even the pig tribe are limited to certain districts, though the wild boar has a wide range. In America there is hardly one native species resembling any of these. The tapir represents the elephant, but is much smaller. The peccary represents the hog. The horse and ass have been introduced, and have overrun the great plains of South America, displacing other animals. Of ruminants there are also distinct groups. The camel is represented by the llama. The goat, the sheep, the ox, and other domestic animals have been introduced and flourish, but there was nothing resembling them when America was first discovered. The great multitude of antelopes and deer (of which there are whole groups of species common in eastern Asia, and others in Africa altogether distinct) are quite unrepresented in the warmer parts of America; and it is only in the far north, where the lands of America and Asia almost touch, that we find the elk and reindeer extending from one continent to the other. The giraffe is African only. Of the monkeys there are two very well-marked groups, distinguished by the use of the tail. The American kinds all make use of the tail as a fifth hand; the Asiatic and African kinds do not, but they differ considerably among themselves. The gorilla, chimpanzee, and baboons are as different from the Asiatic monkeys as are the spider monkeys, weepers, and howlers of the Brazilian forests. The rodents or gnawing animals and the bats are totally different. Of the edentates there is barely a representative species out of America. The marsupials are very imperfectly represented either in Asia, Africa, or America, and are not found in Europe. Australia contained scarcely any indigenous

quadrupeds when discovered, except those belonging to the marsupial tribe. It had not a single ruminating animal. It was the country of pouched animals, as South America was the country of the edentates; but almost all the various classes of quadrupeds were in a certain sense represented among the pouched animals, so that it rather represented an entire kingdom than a province.

It is not only in regard to quadrupeds that the world is divided into several distinct natural history provinces, having little, if any, community of species. Even in birds, something of the same kind may be observed. The humming-birds are essentially American, not confined to any part, but not ranging into any other country. The ostrich is African, extending into Arabia. The whole tribe of birds of brilliant plumage are tropical and Asiatic. Singing birds are almost confined to Europe and the Mediterranean shores of Africa. Reptiles exhibit the same general peculiarity. The crocodiles of Asia and America are altogether distinct. The boa-constrictor of South America corresponds to, but is very different from, the pythons of Africa. Even the frogs and lizards of the two hemispheres are quite distinct; so are the turtles and tortoises. The fishes of the northern seas and those of warm latitudes are not at all the same, many species being limited to a small extent of ocean, others ranging widely, but constantly returning to the same waters to breed. The fresh-water fish are strictly limited in position; but these, like other animals, are capable of being transported to distant climates, where, if the circumstances are favourable, they may extirpate the native inhabitants.

Among invertebrate animals the molluscs are chiefly inhabitants of the water, and the radiata almost exclusively so. Most of the crustaceans also are aquatic. The insects (articulata) are for the most part land animals, living part of their life in the earth and part in the air. All are distributed in groups. Some few species range widely, but the rest are very strictly limited, and are confined often to very small districts. Each species and natural group is adapted to the existing conditions, whatever they may be; and if these change the race disappears, rarely migrating to any great distance. Still, when there is an opportunity, certain species occasionally find an entrance into a district already peopled, and displace the native tribes. Some insects, such as locusts, whose habits are essentially migratory, range over nearly two thousand miles of country, but do not take the place of other insects. Others, as the tse-tse fly of South Africa, cannot cross a river. On the whole, the invertebrata mark with tolerable distinctness the outlines of natural provinces.

Of the great natural provinces, it may be supposed that oceans, great mountain chains, deserts, and great rivers are natural boundaries, at least so far as land animals are concerned, while continents alone separate marine faunas. To a certain extent, no doubt, this is the case. Few large animals, except some birds of powerful wing, can cross mountains or oceans, and the barrenness of deserts is an effectual barrier. Few rivers are important enough to separate regions. But though to a certain extent this is so, there are important exceptions. Some regions exist which are not so separated, and others seem to enjoy a community of

animal species in spite of them. No part of the world is more remarkable in these exceptions than the islands of the Indian Archipelago and Australia. The whole of the islands of Eastern Asia and the Pacific are in this respect worthy of careful study. In most countries islands possess the flora and fauna of the nearest continent. This is not the case when we have passed the coasts of Central and South America and entered the Pacific. Among the islands of the Indian Archipelago there is a line of demarcation, consisting of a few miles of deep water, only observable by its results; and there is a similar line in the interior of Africa, between the east and west tropical coasts, although there is no chain of mountains to cut off the communication. Notwithstanding this, the faunas are very different. No doubt there exist some connecting links between districts thus separated, but the separation is not the less distinct and real.

It might be expected that in illustrating the various floras and faunas our illustrations should be drawn from the countries most familiar, but owing to the long-continued interference of civilized or semi-civilized man in these countries, they are in fact those least adapted to give useful information. Certain races of animals seem especially useful to man, and most of them admit of enormous variations, while some of the varieties are capable of accompanying their master to climates widely different from those natural to them. Thus in Europe we find a mixture of plants and animals from all parts of the world. Our trees and plants are more foreign than native. The cattle we possess, if originally native, have entirely lost their original

character. The sheep, if European, were derived from a stock of which the *mouflons* of Sardinia and Corsica are the only remaining examples. The fox, the wolf, the black bear, the badger, the wild cat, the wild boar, and the beaver were all once inhabitants of European forests. Except the fox, they are now almost extinct, except where the population is still scanty. Of all the European quadrupeds (less than 200 in number) only about sixty are peculiar to the Continent, and of these none are large. Of the birds the same may be said, the domesticated varieties being the most important, and they are all introduced. The number of reptiles is small, and the species unimportant. The variety of fish round the European shores is, however, extremely remarkable, and the kinds include most of those useful to man. Europe is not much more instructive in its invertebrata than in its vertebrata in illustrating the distribution of animals, although, on carefully comparing these, many remarkable indications of the source of the flora and fauna may be traced.

Asia is even more remarkable in this respect than Europe. It includes two natural history provinces, one north and the other south of the great mountain chain. Some of the larger carnivora, as the tiger, pass across the mountains, and range far to the north. Others, as the elephant, do not extend far, being limited to the peninsulas of India and Malacca, with the island of Ceylon. Others, as the camel, range very widely. The deer tribe, including the antelopes, are widely dispersed, numerous, and chiefly found in the western countries. Vast numbers of birds of brilliant plumage and many reptiles

are characteristic. The plants are eminently characteristic also.

Africa, with Arabia, includes two or three sub-provinces, forming one great kingdom. Africa is exceedingly rich in quadrupeds, especially carnivora, ruminants, and pachyderms, and in monkeys. There are about one-fourth of the whole number of known species found in Africa, and a large proportion are confined to that continent. Birds are also exceedingly abundant, and their plumage very brilliant, while reptiles, though represented by some very remarkable serpents and by crocodiles, are not so abundant. Insects abound, and are characteristic.

Another very distinct province exists to the south-east of Asia, connecting the plants and animals of Asia with those of Australia. But the mixture is very imperfectly effected. Orchids, zamias, bamboos, tree ferns, and numerous tropical fruits, the india-rubber, or caoutchouc tree, the camphor tree, and many others, mark the Asiatic character. Across a sea fifteen miles wide we reach the comparatively poor and barren flora of Australia, accompanied by the singular array of kangaroos and other pouched animals, representing in a strange way the faunas of other parts of the world.

America, although one in many respects, and having not a few species and many genera common almost throughout the continent, in spite of its vast extension in latitude, has great differences, both of vegetable and animal life, corresponding with its varied climates. Brazil is a country that is exceedingly rich in life, and is a sub-province of considerable importance. But all tropical America is remarkable. Its quadrupeds are few and poor, but

its birds are remarkable for size and strangeness of form. The turkey, now so common in Europe, is from Mexico; the condor of the Andes is one of the noblest of birds of prey; the humming-birds are unrivalled. Reptiles are very abundant, and many of them poisonous. Most of them are not only different in specific character from those of other countries, but there is little or nothing beyond general structure to identify them. Sub-provinces exist in North America.

Besides these principal divisions, there are very many subdivisions containing natural history groups. Almost every country exhibits some of these. Large countries frequently exhibit several. Here and there dotted about the world are spots which seem to be the birthplace of some curious group or rare species. From this the species extends alone, or accompanied by others, with more or less vigour, and thrusting out others as it advances. The whole world seems peopled in this way. Plants and animals have taken advantage of every opportunity to establish themselves at the expense of their neighbours. As the seasons change, as the conditions of life in a district alter, so do the plants and animals become modified. This is the great struggle for existence, and this kind of struggle has always gone on from the creation of the world. In this great struggle every living thing enters and takes its place according to its strength and resisting power. Certain tribes, assisted by man, make their way, and establish themselves in spite of natural conditions, but they only do so as long as the assistance is granted.

It must not be lost sight of that animals, as well as vegetables, are distributed in vertical space accord-

ing to the same general law as that which affects them in regard to latitude. Thus, in rising to a high table-land, or on the slopes of a high mountain, the replacement is in a general sense similar to that observed in passing from a latitude near the equator to one near the pole. Thus the monkey, which is found in Africa, near the equator, up to a height of 12,000 feet, barely reaches the level of the sea, in the latitude of Gibraltar. In Europe, as in Asia, the ruminants, of which the goat and sheep are representatives, reach generally almost to the snow-line in all latitudes, at whatever elevation the snow-line may be. Even birds obey this law; and among fishes and other inhabitants of the water, depth corresponds to height in determining the corresponding regions. Thus the distribution of plants and animals in space, although it seems at first to involve many intricate and troublesome problems, really resolves itself into a question of favourable conditions of existence. The introduction of life takes place where circumstances are favourable for the development of the germs which appear to be everywhere present. The nature of the life is to a very great extent determined by the temperature, the moisture—in a word, the climate. This is not the same in any two stations, nor does it remain the same for long together. Thus species are being continually altered, destroyed, and replaced, and this constant change is the law of nature, not in any sense the result of accident or an occasional incident in the history of the world.

CHAPTER IX.

DISTRIBUTION OF THE HUMAN RACE.

THE position of man on the earth is very peculiar. He is one of its later inhabitants, and appears to exercise a disturbing influence of a different and much higher kind than any other animal. He is also much more independent of change of climate than any other animal of complicated organization. Capable of advancement in civilization under certain circumstances, and most capable of enduring change when most civilized, the human family seems now divided into certain natural groups, having very strongly marked characteristics, and among the rest a very different susceptibility to civilization. But this, after all, may be more apparent than real, for it is one of the peculiarities of the human race that its members may remain in a state very little removed from intelligent quadrupeds or monkeys for an indefinite time, and then suddenly, and with great rapidity, start into a high condition of intellectual activity. Thus, in the study of the human race and its influence, we are met at the outset by great difficulties, which are not easily mastered.

The human race, in a savage or uncivilized state, appears to have existed on the earth for a very long period. Existing records go back only a few thousand years (five or six thousand), at which time the race, or some families of the race, had already grown out of barbarism into intelligence. There were then

racés who could and did cultivate food-plants, use mechanical powers in building, and exercise much ingenuity to escape from their enemies. This degree of intelligence was at that time very well established in several districts; and very soon afterwards there is proof that many of the distinctive marks that characterize some of the families of men existed as strongly as they have done since and do now. These include peculiarities of structure and colour. Whether they are essential, and mark what is called species, it is not necessary here to consider. They exist, and by them we still distinguish the different divisions of the human race. The pyramids of Egypt, and human remains found in caverns, are among the most instructive monuments in these matters.

It appears from discoveries made in gravel and caverns, that man lived in Europe when the climate admitted of the existence at the same time in Southern Europe of the reindeer and the elephant. The climate must then have been totally different from any existing European climate, and since then many old species of the animals of the period have become extinct. The men of those days, after remaining apparently without much improvement, while great natural changes were going on, and migrating, it may be, from time to time in search of food to fresh countries, either died out and were replaced by others, or it may be that the higher faculties of these same races were at length awakened, and intellectual growth commenced. To their mere animal power the earlier races added the use of natural agents; they domesticated and employed certain tribes of animals; they cultivated the land; they began to

build in a style capable of enduring through many generations; and thus commenced the history which has now been going on for many centuries, and which has resulted in the extreme advance of a few races, with little change or improvement in many large natural families.

But when we endeavour to make out how far the human tribes of different countries resemble each other, and wherein they differ, we are once more involved in great difficulties. The people of England, in their present state of civilization, differ from those of France. There is such a thing as national character, and each nation possesses its own. Even the national character of the English, Welsh, Scotch, and Irish, all inhabiting one small group of islands, is known to differ exceedingly. This may be explained by saying that the people are differently derived, but this only throws back the difficulty one step farther. Who were the ancestors of these peoples? Whence did they come? and why did they occupy these islands? These are questions that cannot be answered by any historical authority, and we are reduced to study the only records that really remain—the roots of the languages they speak. Thus the department of Physical geography we are now considering is almost more a branch of literature than of natural history.

There are at the present time a certain number of groups of the human family very distinctly marked. They differ in actual structure, having many parts of the bony framework of the body, the colour of the skin, and the colour and texture of the hair so distinct as apparently to justify us in separating them as species. But, on the other hand, differences at

least as great are produced by man himself on domesticated animals, especially the horse, the dog, and the horned cattle. It is true that the various groups differ also in the power of reasoning and in intellect, but not more in all probability than did the early races of men, before they were civilized, from their civilized descendants in Europe. Thus we are unable in this way to come to any satisfactory conclusion on the subject of specific differences amongst the human race. It is not necessary for our present purpose that we should decide the question.

The following are the groups or families of men generally recognized:—1. The *Caucasian*, or bearded type, of which the Europeans of Germany, including Scandinavia, England, and France, are the best examples. 2. The *Mongolic*, or beardless type, represented by the Central Asiatics and Chinese. 3. The *Negro*, or woolly haired type, from tropical Africa, especially the Delta of the Niger. The *American Indians* and the *Malays* are sometimes separated from the Mongolic type, and regarded as distinct groups. These varieties are on the whole so distinct from each other that the first impulse of any one examining extreme cases would be to deny any natural specific identity. The differences are partly of colour, which are shades of white, yellow, red, and black respectively; partly of hair, either straight, silky, and with a wavy curl, straight and lank, or curled like wool; partly of the shape of the cranium, or that part of the skull containing the brain. In one group the cranium rises straight from the face, or nearly so; in another it goes back moderately; in the third, or negro, it recedes considerably, and in this respect approaches the gorilla or monkey tribe. There

are also differences in the structure of the pelvis and other bones, which in all cases depart most from the monkey character in those races which have advanced most in civilization.

It would appear either that there are different races of men, some naturally more capable of intellectual advance than others, or that the varieties have become so far fixed in certain localities, owing to peculiarities of climate and the conditions of existence, that when an attempt is now made to produce a modification, the inferior race dies out before the change is effected. This at least is the experience of all recent migrations of civilized races to countries previously inhabited by savages. It is quite unnecessary to consider here the very difficult and obscure questions as to the nature of species, and the extent of variety that is equivalent to species, nor is it possible in the present state of science to decide positively what is the real nature and extent of the difference between the families of men, when or how they began to diverge, whether all were derived from one pair, or what is the cause of the susceptibility to intellectual improvement shown by some races, and of the apparent want of power to improve under education manifested by others.

It must not be supposed that it is only those races with which we are most familiar at present, and who inhabit the countries west of the Caucasus, which are alone capable of high civilization. The Mongolic nations of China and Japan, of parts of Asia Minor, and of Central America and Peru, have undoubtedly advanced very early and very far in intellectual culture. Even the negro races have been among the greatest benefactors to mankind, if, as is supposed by

some ethnologists, the ancient Egyptians and Copts, and the inhabitants of Palestine, the Jews, ancient Babylonians and Assyrians, and even the Arabs, are to be referred to them. To these races we owe our alphabetic writing, our numerals, and many other ingenious inventions, without which intelligence could hardly be communicated. The races called Caucasian were certainly among the latest to be civilized, and we cannot tell how much they owe to those whose civilization preceded our own.

The races called Caucasian have really little or nothing to do with the mountain chain of the Caucasus, for the inhabitants of these countries are Mongolic, and the races dwelling in the adjacent countries were derived from the negro. These races include a mixture of the inhabitants of the peninsula of India and the valley of the Ganges with those of the valley of the Euphrates, combined with the Germanic races of northern Europe. They are sometimes called Indo-Germanic instead of Caucasian. They consist of (1) the Germans of all kinds, including the Dutch and the Scandinavians; (2) the Slavonic races of Russia, Poland, Servia, and Illyria; and (3) the Mediterranean groups of Greece, Italy, Spain, France, and Wallachia. The Celts, formerly present in abundance, and overrunning this country, have been gradually driven westward, and are now few in number. The English, or true Anglo-Saxon race, is a mixture of all these. The Caucasian races are the least numerous, and occupy far the smallest tract of country, but are the most influential of all.

The Mongolic tribes may conveniently be subdivided into the Mongols proper, the Malays, and the American tribes. They occupy a very large part of

Asia, and originally peopled the whole of the islands of the Indian Ocean and the Pacific, and the whole continent of Australia. They also inhabited both North and South America. A very large number, perhaps even a large proportion, of the various races have been driven out and destroyed during the last four or five centuries by the colonizations of the Indo-Germanic people; but they include important emigrant races. Several divisions of the Mongols have been made out. The first includes two groups: (1) The Chinese, Burmese, and others adjacent; (2) the Tartars, Turks, Hungarians, and Laplanders. These two have many points in common. The second division includes the inhabitants of Western Asia and the Caucasus. The third division (sometimes regarded as a different type) includes the Malays and Australians; the fourth, the inhabitants of northern (Arctic) Asia; the fifth, the Japanese; the sixth (also sometimes regarded as a type), the American Indians. There are several groups of these latter races, some connecting with the northern Europeans and Asiatics by the Esquimaux, and some confined to Central or South America.

The Negro type of man also presents several groups. The typical, or most characteristic, are the lowest in development. They inhabit the low unhealthy lands at the mouths of rivers on the west coast of Africa. With some variations of character and appearance they extend thence into the interior, and range both northwards and southwards, thus occupying the whole of Africa, and only extending beyond that continent when carried as slaves either into Arabia or to America. The southern varieties—the Kaffirs and Hottentots—are distinct, and equally

low in intellect with those on the west coast. The eastern tribes north of the equator are much more intelligent. They include the Gallas, the Nubians, and the Copts.

The migratory instincts of the mixed races settled in Western Europe have been so active within the last few centuries, and have been so assisted by mechanical inventions and the progress of trade within the present century, that the balance of population in some large tracts of the earth has been entirely altered. This is especially the case in North and South America, the West Indian Islands, and Australia, and New Zealand, and South Africa. The native population over vast tracts of the earth is already displaced, and has either disappeared or will shortly disappear. In this way the distribution of various races is undergoing great change. It must not be supposed, however, that migrations of this kind are new on the earth. Something of the sort has happened many times, even in the historic period, and doubtless often before. Certain races of men possess the migratory instinct almost in the same way that certain quadrupeds, birds, and insects migrate. They multiply, food becomes scarce, and the young go away in search of other and generally more fertile lands. Other men and animals show no disposition to pass beyond certain narrow limits. Migrating races, being of necessity energetic, conquer the races already settled, even when they themselves were originally emigrants; and thus either an influx of barbarism—the introduction of a rude people endowed with energy—takes the place of a less energetic race already civilized, or a civilized people replaces a community of savages. In the former

case, as when the northern tribes entered and conquered Italy, the civilization of the conquered people, although checked and even partially lost, produced an effect on the Gothic and German invaders that ultimately resulted in the growth of an equally high, though very different civilization, perhaps of a more enduring kind. In the latter case, as when the Spaniards invaded South America and the West Indian islands, the native tribes were almost extirpated, except in a few places, where a mixed race has established itself. In North America the Anglo-Saxon race has already almost annihilated the native Indian tribes, and bids fair to occupy the whole country from one end to the other. So it is in Australia with the least intelligent and most hopeless of savages, and so it will be in New Zealand with the most intelligent of the inhabitants of the Pacific islands. It is chiefly in temperate climates that this absolute displacement has taken place; but tropical America contains very few of its original inhabitants, who have been replaced by a mixed race, if they have not been altogether driven out and annihilated. No attempt has yet been made to colonize India; and there the impress of foreign rule is not likely to last much beyond the occupation itself. No Anglo-Saxon colonization of Central Africa, or of the tropical shores of Africa, can be successful, as the white children born to Europeans cannot resist the climate.

The civilization of the Chinese and Japanese, and of the native inhabitants of India, is extensive, and of very long standing, but is less material in its direct results than that of the Western people, and has long ceased to advance. These people are also

less aggressive, and have rarely migrated, in spite of increasing population. There are thus different kinds of civilization, depending on the peculiarities of character of the different people.

Man produces great changes on those parts of the earth that he inhabits. Even uncivilized savages dwelling on the sea-side have left on the shores of Scandinavia and Scotland numerous hills, made up of the shells of the shell-fish and crustaceans and the bones of the animals they lived upon. With these vast piles are found occasionally the weapons and fragments of the utensils they employed. When men become civilized, and live in towns, they soon begin to cut down the timber, which originally clothed the great plains, the valleys, and the hill-sides in temperate climates; and the removal of these forests has done much to alter the distribution of rain, and in this way has modified the climate. Afterwards, when civilization advanced farther, and the cultivation of the land was seriously undertaken, the further result of drainage of the land tends in the same direction. The removal of the forests involves the disappearance of many animals of all kinds, whose natural places of abode are thus entirely lost, and, on the other hand, the introduction of animals of other kinds capable of being domesticated, and derived from distant countries. To replace the forests, trees bearing fruits available for food, or useful for other qualities, are planted where the soil is not occupied by the grasses, roots, and other food-plants yielding annual crops. In this way the birds are affected. Some birds and some small quadrupeds are destroyed as mischievous, others are introduced because they are useful, and others follow inevitably in the train of

civilization, whether useful or mischievous. Even the insects are affected, and the drain on the supply of certain animals as articles of food ends by exhausting even the vast reproductive power of nature. The influence of man thus unconsciously asserted is enormous. It acts in directions which he never anticipates, and sometimes can hardly follow. It is partly direct, but to a very great extent indirect. It extends much more widely than is generally supposed, and it has gone on in most countries much longer than we might be inclined to suspect.

It is quite certain that the permanent climate, the temperature, and the various atmospheric conditions that conduce to form climate, are very seriously modified by the changes that take place when a country before uninhabited by man, or inhabited only by savages, becomes settled and inhabited by civilized cultivators of the soil. There are proofs of this in every country where civilization has established itself. The proofs in Europe are numerous and striking. The result is not by any means favourable in all cases. The forests removed have perhaps served as shelter for a more delicate vegetation, which must now fail. Winds have been diverted and checked, which, when left to blow freely over the land, would dry up and destroy, whether by scorching or freezing, the growing crops. The general result is that the surface flow of rain, at one time greatly interrupted by small swamps and pools, now runs down at once to a main stream or to the sea, so that the earth is drier, and more readily feels the effect of the sun. The swamps are drained, and the rivers run with more rapidity, and act more powerfully both in carrying down mud and sand to the sea,

and in eating out fresh channels. The climate is thus rendered more extreme, and in some cases more severe. So clearly is this the case that in some places replanting has been resorted to with success for the purpose of restoring a climate unfavourably affected. When once, however, the forests are gone, the rainfall diminishes, and thus the springs are lowered. The effects extend very far beyond the district in which the alteration has been made. By confining streams to a narrow bed, and obliging them to follow continually the same course, the distribution of the solid matter brought down by the stream is altered, and thus the mouths of a distant river may feel the change produced. By the draining of swamps at the mouth of great streams a large tract of land is taken from the sea and brought under cultivation, and thus a muddy expanse is converted into a fertile country.

Other results are occasionally seen of human occupation. Fire is so constantly used by man in all countries that it cannot excite surprise if it should occasionally do serious injury to large tracts of country. There are cases on record in which many thousand square miles of woodland have been destroyed in a very short time by a conflagration. These destructive results are indeed of no lasting injury, for in a few years the ground is covered with a fresh growth; but the trees that grow out of the ashes of the old forest are of a different kind, and thus the face of nature is changed.

Few people are aware of the enormous amount of change that has been thus introduced. Probably no country in Europe or Asia has now the same climate and the same general distribution of plants and

animals it would have had if man had not been the head of creation, exercising an unconscious as well as conscious authority and influence over all. Not powerful as an individual, if mere physical power is alone considered, he is comparatively unimportant till he begins to exert his superior intellectual faculties to bring about his will and intention. When this is commenced, he is enabled to take advantage of the experience of those who have lived before him, and also to induce his fellow-men to work with him when he desires to attain a great result. Thus he can and does (1) turn the course of rivers; (2) drain lakes and produce fertile land where there was before only swamp; (3) build habitations and construct walls and buildings which remain unchanged for thousands of years; (4) displace and render locally extinct a multitude of animals and plants which cannot make head against his approach.

But we must remind the student that all animals and plants in their degree are also capable of modifying the face of nature. None, it is true, do so to the extent of civilized man, but this is simply because they are less intelligent and have fewer needs. It is a law of nature that a balance should be kept among the various forms of life, animal or vegetable. Each not only occupies its own place, but tends to occupy more, because the law of increase governs all. More seeds are sown than would replace the number of plants or trees of whatever kind that annually die. Either the young plant or animal must drive out and weaken other kinds, or they must be destroyed themselves. Familiar as this is, it is not sufficiently remembered. A tree falling may alter the direction of a stream, or may produce a swamp. Another

series of events may convert a swamp into a river-bed. A fire accidentally produced may burn a vast forest of one kind of trees, and immediately there will spring up a forest of another kind. A flood may destroy many individuals of a certain kind of plants and animals, and render the ordinary habitations of many others unfit for their use. Another tribe steps in, replaces them, and tends to destroy them. This kind of change goes on everywhere without the interference of man. Man steps in and does the same thing, perhaps more systematically, perhaps on a larger scale, but he must not suppose that he interferes with the laws of nature; he merely follows them, and produces results exactly corresponding with his own special nature and organization. The law of nature is to preserve a world full of living things adapted to their nutrition and use, by taking care that each time there is a blank it shall be filled up, not necessarily by the young of the same, but by whatever is at hand best fitted for the purpose. There is no hesitation or delay, no waiting while the old form is replaced. Everywhere there is something ready, and that something is the best and most adapted to the requirement of the moment. Even decay is only replacement, and death is only a name for another kind of life.

GLOSSARY;

OR

EXPLANATION OF TERMS USED IN PHYSICAL GEOGRAPHY.

- ACCLIMATIZE.** To adapt a plant or animal to a new or changed climate, whether by a natural process or artificially. A certain amount of time is generally required; and only certain kinds and amounts of change seem at present possible.
- AERIAL.** (Greek, *aër*, the air.) Relating to the air.
- AEROLITE.** (Greek, *aër*, the air; *lithos*, a stone.) A stone, or fragment of solid matter, that has fallen to the earth through the air, coming from outside our planet. Such fragments are portions of matter revolving in orbits in groups of various dimensions, and fall when they are present in a part of the orbit of the group crossing the orbit of the earth.
- AFFINITY,** in Natural History. The relationship that exists between species of the same genus or genera of the same family. Affinity is not necessarily exhibited by external resemblance.
- AFFLUENT.** (Latin, *ad*, to; *fluens*, flowing.) A tributary stream, or a stream flowing towards and ultimately absorbed into another and larger stream or river.
- AIGUILLE.** (French, a needle.) A pointed mountain peak.
- ALLUVIAL DEPOSITS, ALLUVIUM.** (Latin, *alluo*, to wash.) The material left behind by rivers in their ordinary flow. See **DILUVIUM**.
- ALP.** The name given in Switzerland to the high feeding places on the lofty mountain chain of that country, thence called the Alps.
- AMORPHOUS.** (Greek, *a*, without; *morphe*, form.) Not crystalline, or having no strictly definite natural shape. Rocks are generally amorphous, sometimes crystalline.
- ANALOGY,** in Natural History. Resemblance of form or structure, independent of affinity or true relationship. See **AFFINITY**.
- ANEMOMETER.** (Greek, *anemos*, the wind; *metron*, measure.) An instrument for measuring the force and direction of the winds.
- ANEROID.** (Greek, *a*, without; *neros*, wet.) A barometer without fluid. See p. 10.
- ANIMALCULE.** A very minute animal.
- ANTARCTIC.** (Greek, *anti*, opposite, and *arctic*.) Opposite the Arctic or North Pole. See **ARCTIC**.
- ANTHROPOLOGY.** (Greek, *anthropos*, man; *logos*, an account.) The science of man regarded in his natural history capacity.
- ANTIPODES.** (Greek, *anti*, opposite; *pous*, *podos*, a foot.) The inhabitants and places exactly opposite any part of the earth. Being a globe, those who dwell on opposite sides of the earth have their feet towards each other, the world being between.
- AQUATIC, AQUEOUS.** (Latin, *aqua*, water.) Relating to water.
- ARCHIPELAGO.** (Gr., *archi*, chief; *pelagos*, the sea.) A considerable group of islands.
- ARCTIC.** (Greek, *arctos*, a bear.) The stars of the constellations or groups known as the Great and Little Bear, point to the North Pole,

which is therefore called Arctic. As the North Pole is covered with ice during a great part of the year, the term is also used to express cold.

AREA. (Latin.) An extended space.

ATMOSPHERE. (Greek, *atmos*, vapour; *sphæra*, a globe.) The whole body of the air or mixed gases surrounding and enclosing the earth. The atmosphere diminishes rapidly in density or quantity of matter in ascending, and at a distance from the earth, estimated at about a hundred miles, it ceases to be appreciable in its action on light. After that it passes gradually into Ether.

ATOLL. (Malay.) A coral island, in which a ring of coral surrounds a circular pool or lagoon of salt water.

ATOM. (Gr., *atomon*.) An exceedingly minute particle.

AURORA. (Latin.) Flashes of electric light seen in high northern and southern latitudes, and proceeding from the magnetic poles of the earth. In the northern hemisphere, the appearance is called Aurora Borealis; in the southern, Aurora Australis. The light is seen occasionally almost as far as the equator.

AVALANCHE. (French.) A fall of a large body of snow from the edge of a precipice or the upper part of a valley upon the plains below. Partially melted snow, with gravel and stones, sometimes accompany the avalanche and form part of it.

AXIS. (Latin, a pole or axle-tree.) See p. 3.

BAROMETER. (Greek, *baros*, weight; *metron*, measure.) An instrument for measuring the pressure or weight of the air. See p. 10.

BASIN. A word used in physical geography, when speaking of the part of a country enclosed in a line within which all the water that falls as rain runs into one general depression or valley. Thus the basin of the Thames is the area which that river drains. The basin of the Mediterranean is the whole area that drains into that inland sea. The basin of the Atlantic includes all rivers draining into that ocean.

BATRACHIAN. (Greek, *batrachos*, a frog.) Relating to frogs.

BAY. (Saxon.) A wide recess of a coast line into which the ocean enters freely.

BEACH. (Saxon.) The part of a sea shore alternately covered with water and left dry.

BIOLOGY. (Greek, *bios*, life; *logos*, an account.) The science that treats of the phenomena of life.

BITUMEN. (Latin.) Mineral pitch, obtained in some places in considerable quantities from natural sources.

BLUFFS. (American.) The name given to the high vertical banks of certain rivers.

BORE. The advancing front of a high-crested wave, derived from the tidal wave, running between high banks or cliffs, gradually narrowing, and over shoals. It is sometimes 30 feet high, and advances at the rate of 25 miles an hour. It is sometimes called *egrr*.

BOULDER. A naturally rounded block of stone on or within the earth, but not belonging to the rocks immediately below. Boulders have sometimes been transported to countries very distant from the parent rock.

BREEZE. A brisk wind, of limited extent and small violence.

CAÑON. (Spanish.) The name given in Central America and California to deep narrow ravines or gorges in table lands of limestone.

CARDINAL. (Latin, *cardo*, a hinge.) A turning-point or essential thing. In geography, the word is used in reference to the four points of the compass, as being matters on a right knowledge of which so much depends.

CARNIVORE, or CARNIVOROUS. (Latin, *carnis*, flesh; *voro*, to eat.) Flesh-eater, or flesh-eating.

CEPHALOPODA. (Greek, *cephale*, head; *pous*, a foot.) Animals whose organs of locomotion (feet) are placed around the head.

- CHALYBEATE.** (Greek, *chalybs*, steel.) A term applied to waters containing a sensible quantity of iron in solution.
- CHANNEL.** The course of a river, or the part of a strait through which a current flows.
- CHAOS.** (Greek, without order.) The condition of nature before order was introduced by the subjection of matter to law. *See* COSMICAL.
- CHART.** (Latin, *charta*, paper.) A map showing the outline of a coast, and all the known facts concerning the sea, the openings by which the sea enters the land, and those by which rivers enter the sea.
- CLEFT.** An open cut or fracture in a rock, producing in many cases a valley.
- CLIMATE, CLIMATOLOGY.** (Greek, *clima*, an included space.) A term originally limited to belts or zones on the earth, including all places having equal lengths of day. The modern meaning in physical geography will be found explained in p. 108. Climatology means an account of climates.
- CONFLUENT.** (Latin, *con*, with; *fluo*, to flow.) A tributary stream to a larger river.
- CONIFERÆ.** (Latin, *conus*, a cone; *fero*, I bear.) An important natural family of plants whose fruit has a conical form. Such are the firs, pines, yews, &c.
- CONTINENTAL ISLANDS.** Islands situated near a continent, and not separated by deep channels of blue water. The British islands are of this kind.
- CONTOUR.** (French.) The shape of the land, or that part of the earth situated above the level of the sea. Lines parallel to the sea-lines round a coast, and at a higher level, are called contour lines; and in some maps these are marked to show elevation above the sea.
- CORDILLERA.** (Spanish.) A name applied to the important mountain ranges in South America and elsewhere.
- COSMICAL.** (Greek, *cosmos*, order, method, and thence the world or the ordering of nature.) Relating to the great laws that govern nature. Many large and complicated phenomena are called *cosmical*, to express their harmony with the general plan of the universe. *Cosmos* is used in contradistinction to *CHAOS*.
- CRANNOGES.** The Irish name of the remains of Lake Dwellings, which *see*.
- CRATER.** (Latin, a cup.) The cup-like summit of a volcano.
- CRUST of the earth, or EARTH'S CRUST.** That part of the earth open to observation. It includes not only the depth reached by mining operations and wells, but the total thickness of strata shown in consequence of their having been pitched up at a high angle.
- CRYSTAL, CRYSTALLIZATION.** (Greek.) A crystal is the regular solid form in which substances tend to arrange themselves when at liberty to do so without interruption. Thus salt crystallizes when obtained from water in which it has been dissolved. Crystallization is the act of being converted into a crystal.
- CULMINATING POINT.** (Latin, *culmen*, the top.) The highest point of a mountain range.
- CURRENT, marine.** A portion of the water of the sea in which there is a perpetual onward motion of the water at a certain rate per hour, quite independent of the accidental and occasional movements of the whole body of the water or of any part. There are many such currents in the ocean, some carrying warmer and some cooler water than the sea adjoining. They are of limited depth. The Gulf stream is a familiar example.
- CYCLONE.** (Greek, *cyelos*, a circle.) A name given to a peculiar class of storms known in the West Indies as *hurricanes* or *tornadoes*, in the China seas as *typhoons*, and by other names elsewhere. The storms thus named travel along a certain course, and twist round rapidly as they advance. The centre of the storm travels in a straight or curved line, but every other part of the storm has a corkscrew motion.

- DEFILE.** (French, *defiler*.) A narrow pass between natural obstacles.
- DEGRADATION.** (Latin, *de*, from or down, and *gradus*, a step: removing by degrees.) A word used technically in physical geography to signify the gradual wearing away of land by the action of water.
- DELTA.** (The Greek letter Δ, pronounced *della*.) The triangular tract of flat land deposited at the mouth of certain large rivers, where the fresh water, carrying down mud and stones, comes in contact with, and is checked in its rate of motion by, the salt water, whence the deposit.
- DENUDATION.** (Latin, *de*, from; *nudus*, naked.) Laying bare or wearing away by the action of water.
- DEPOSIT.** (Latin, *de*; and *positus*, placed.) In physical geography and geology, the matter thrown down or left behind by water, after being carried along some distance, is called a deposit.
- DESERT.** (Latin, *desertus*, uninhabited.) A waste place. In geography, it is especially applied to large tracts of sand or shingle within a continent or large island, uncultivable, and therefore uninhabited. Deserts are generally without water.
- DESICCATION.** (Latin, *de*; and *siccus*, dry.) The art of drying up by evaporation.
- DETRITUS.** (Latin, *de*; and *tritrus*, rubbed.) The material rubbed or worn away by the action of water, and left behind, after being conveyed some distance.
- DIATHERMIC.** (Greek, *dia*, through; *thermē*, heat.) Permitting heat to pass through. The term, as applied to heat, corresponds with transparent as applied to light. Thus rock-salt and ice are both transparent; but while rock-salt is diathermic as well as transparent, allowing heat as well as light to pass freely, ice, however transparent, allows hardly any heat to pass through, and is not diathermic.
- DICOTYLEDON.** (Greek, *dis*, double; *cotyledon*, a seed-leaf.) Plants having seeds which, when they begin to grow, split into two, the young plant rising from between the two parts or lobes, are called *dicotyledonous*. Such plants increase during life by additions to the outside, and the veins of their leaves are not parallel like those of grasses. Our common forest trees are of this kind. They are also called *Exogens*, which *see*.
- DILUVIUM.** (Latin, an inundation or rush of water.) The deposit left behind by occasional floods of water, as distinguished from *alluvium* (which *see*), which is deposited from the ordinary flow of water.
- DISINTEGRATION.** (Latin, *dis*, asunder; *integer*, whole.) The breaking up of solid rock, generally by the action of water and frost, assisted by chemical means.
- DOWNS.** Rounded hills, generally of chalk. The derivation of the word is from *dune*, a hill; but that term is now limited to sandhills.
- DRAINAGE AREA.** A district including all the tributaries and feeders of a river from its sources to its outlet, and all the land from whose surface water runs towards any of these streams.
- DRIFT.** (That which is driven or forced along.) In physical geography, the word is used with reference to water, and also to sand forced on by winds. In the case of water, a current is produced, thence called a drift-current. When sand is drifted, it sometimes masks the face of the country. In geology, it has a more extended meaning.
- DUNES.** Hills of blown sand by the sea-side.
- EARTHQUAKE.** A quaking or vibrating motion of the earth, frequently producing cracks in the ground, besides destroying the houses and other constructions built on the surface. *See* p. 113.
- ECLIPTIC.** The orbit of the earth round the sun.
- ENDOGEN.** (Greek, *endon*, within; *ginomai*, to be formed.) Formed or growing from within. The name of a division of plants, including grasses and palms, where growth is by additions to the inside, not by external layers. *See* EXOGEN, DICOTYLEDON, and MONOCOTYLEDON.
- EQUATOR, EQUATORIAL.** (Latin, *æquatus*, made equal.) The earth

being represented by a sphere or ball revolving like a top set going on a table, the *equator* is the part that represents the middle of the top, the upper and lower parts being the poles. The equator is a circle on the earth, every part of which is at the same distance from both poles. At the equator, the days and nights are of equal length all the year round. See p. 4.

EQUINOX. Equinoctial. (Latin, *æquus*, equal; *nox*, night.) The times of the year when the days and nights are of equal length. There are two such periods in the year: one in the spring is called the *vernal* equinox (Latin, *ver*, spring); the other in the autumn, called thence *autumnal* equinox.

EROSION. (Latin, *erodo*, to gnaw.) The act of eating out or eroding as performed by rivers on their valleys, or in forming and deepening the ravines through which they pass.

ERUPTION. (Latin, *e*, out of; *ruptus*, burst forth.) The bursting forth of steam, gas, and other matter from the earth when a volcano comes into active operation. See p. 119.

ESCAR. A name given in Ireland to long flat-topped hills found in some of the river valleys. See *OSAR*.

ESCARPMENT. (French, *escarper*, to cut steeply.) A steep face terminating high lands abruptly.

ESTUARY. (Latin, *æstus*, the tide.) An inlet up which the tide flows and through which a river runs.

ETESIAN. (Greek, *etesios*, annual.) A name given to certain periodical northerly winds blowing in the Mediterranean during spring.

ETHER. (Greek.) The name given to an extremely diffused gas, believed to extend between the different planets and planetary systems throughout the universe. It is so exceedingly thin—in other words, the atoms of which it is composed are so distant—that it does not retard the motions of the heavenly bodies in any calculable degree, but it is the medium through which light and heat are transmitted, and perhaps, also, the force of gravitation.

ETHNOGRAPHY, ETHNOLOGY. (Greek, *ethnos*, a race of men; *graphie*, or *logos*, an account.) The department of natural history which applies to the physical history of the human race.

EVAPORATION. (Latin, *evaporo*, to send off in vapour.) The removal of water by the absorbent action of the atmosphere.

EXOGEN. (Greek, *exo*, without; *ginomai*, to be formed.) Plants growing by additions from without are thus called by Botanists. They are also called *DICOTYLEDONS*, which *see*.

EXOTIC. (Latin, *exoticus*, foreign.) Brought from abroad. A plant or animal removed from a distant country.

FACIES. (Latin, the face.) The general and characteristic appearance of the plants and animals of a district.

FATA MORGANA. (Italian, the fairy Morgana.) A peculiar atmospheric effect seen occasionally in the Straits of Messina. See *MIRAGE*.

FAUNA. (Latin.) The whole group of animals naturally living within a natural history province.

FERRUGINOUS. (Latin, *ferrum*, iron.) Containing iron. Looking rusty.

FJORD. (Norwegian.) A long narrow inlet from a great ocean with nearly vertical walls. Many of the so-called lochs of Scotland are fjords.

FLORA. (Latin.) The whole of the plants naturally growing within a district or natural history province.

FLUVIATILE. (Latin, *fluvius*, a river.) That which belongs to a river.

FLUVIO-MARINE. (Latin, *fluvius*, a river; *mare*, the sea.) That which is formed under the joint action of river and sea.

FÖHN. (German.) A warm local wind coming from the south, and occasionally blowing over the south of France, the Alps, and Switzerland. It blows at all seasons, though chiefly in summer. Its effect is often seen in reducing the snow and causing glaciers to retreat up the valley, and it resembles the scirocco of Italy.

- FORMATION.** A term used in geology to signify a complete group of beds or strata.
- FOSSIL.** (Latin, *fossilis*, that which may be dug up.) This word, originally applied to all minerals taken out of the earth, has long been confined to those which have once belonged to a plant or animal.
- FULGURITE.** (Latin, *fulgur*, lightning.) A tube formed by the melting and subsequent cooling of sand through which a flash of lightning has passed on its way from the clouds to moist earth.
- FUMAROLE.** (Italian, *fumare*, to smoke.) A smoking crevice or crack in volcanic rocks, generally consisting of vapour of water, sulphurous acid gas, and carbonic acid gas.
- GALVANISM, GALVANIC.** A form of electricity first made known by Galvani, an Italian physician.
- GEYSIRS.** (Icelandic.) Jets of hot water issuing from the earth near the great volcano of Hecla, in Iceland. *See* p. 120.
- GHAUTS.** A local name for the coast ranges of mountain land on the eastern and western sides of the Indian peninsula.
- GLACIER.** (French.) Frozen snow overpassing the snow line, and stretching down into a valley, pushed forward by the weight of the constantly added snow, and only terminating at the point where the melting during summer equals the whole advance of the year. *See* p. 107.
- GLACIERE.** (French.) A kind of glacier or ice-mass formed in some sheltered place during winter, and remaining there during summer, owing to the absence of sun and the bad conductors of heat with which it is surrounded. It is a kind of natural ice-house, generally a cavern, and always at a high level, though not near the snow line.
- GORGE.** A narrow valley or ravine among mountains.
- GRAVEL.** A term used to describe a mixture of moderate-sized rounded pebbles of hard rock and quartz sand, often coloured pink by iron, and generally belonging to the glacial period. This kind of gravel is chiefly common in England.
- GRIT.** A coarse-grained sandstone.
- GROUND-SWELL.** The name given to long deep waves rolling in towards a shelving shore, after severe weather in the open ocean. They are often very destructive, owing to the largeness of each wave.
- GULF.** (French.) A recess of the ocean nearly closed by a promontory.
- HABITAT.** (Latin, *it inhabits*.) The country or district which a species or group of species naturally inhabit. From their natural habitat they sometimes migrate, and it is useful to distinguish the migrated from the indigenous tribes.
- HARMATTAN.** A cold dry wind blowing in Senegambia and Gambia, on the coast of Africa. It is intensely dry.
- HERBIVOROUS.** (Latin, *herba*, grass; *vorare*, to eat.) Feeding on grass or vegetable food.
- HORIZON.** (Greek, *horizo*, to bound.) The line that terminates the view of any person stationed on the earth's surface is called his sensible horizon. The sun and other heavenly bodies are only seen when above it. A person situated at a great distance, looking upon the earth, would see exactly half the earth, and the line round the earth's centre that would be thus seen is called the true horizon.
- HORNITOS.** (Spanish, little ovens.) The Spanish name for low hillocks in volcanic districts, from which issue hot vapours, and sometimes hot mud.
- HORSE LATITUDES.** A region of calms and uncertain winds in the Atlantic, extending beyond the limits of the trade winds. It is so called from the number of horses lost on board sailing vessels endeavouring to transport them from Europe to America, and detained in these latitudes.
- HUMMOCK.** A sailor's term for blocks of ice forming irregular mounds and an uneven surface on a field of ice.
- HURRICANE.** *See* CYCLONE.

- HYDROGEN.** (Greek, *hydor*, water; *ginomai*, to produce.) A gas, one of the component parts of water.
- HYDROGRAPHY.** (Greek, *hydor*, water; *grapho*, to write.) The department of physical geography which relates to the sea, rivers, and lakes.
- HYDROLOGY.** (Greek, *hydor*, water; *logos*, an account.) The department of physical science which treats of water generally.
- HYETOGRAPHY.** (Greek, *hyetos*, rain; *grapho*, to write.) The department of physical geography which relates to all the phenomena of rain.
- HYGROMETER.** (Greek, *hygros*, wet; *metron*, a measure.) An instrument to measure the degree of moisture of the atmosphere. An instrument that determines the fact that the air contains moisture without measuring it accurately, is sometimes called a hygroscope.
- (Greek, *hygros*, wet; *scopeo*, to perceive.)
- ICEBERG.** (German, *berg*, a hill.) A mass of ice and gravel or stones floating in the sea high out of the waters. Such masses have been separated from large glaciers entering the Polar seas. The mass of ice under the surface is nearly ten times greater than that which is above the water line.
- ICE FLOE.** A mass of ice formed in the Polar seas, and drifted into warmer latitudes by marine currents. Ice floes contain no transported earth or stones.
- IGNEOUS.** (Latin, *ignis*, fire.) Produced by the action of heat.
- IMPERMEABLE.** (Latin, *im*, not; *per*, through; *ireo*, to pass.) Not admitting the passage of water.
- INDIGENOUS.** (Latin, *indigena*, a native.) Natural to the country, or produced in it.
- INORGANIC.** (Latin, *in*, not; *organum*, a member.) Not produced by the action of life.
- INOSCULATING RIVERS.** (Latin, *inosculo*, to unite.) In certain great streams, the tributaries at some part of their course connect together by natural canals. This union is called *inosculation*.
- INTERMITTENT.** A name applied to certain springs of water which do not run constantly, or in which the flow varies considerably in amount from time to time.
- INTERTROPICAL.** Situated between the Tropics.
- INVERTEBRATA.** (Latin, *in*, not; *vertebrum*, the back-bone.) Animals not having a vertebral column or back bone.
- ISOCEIMAL, or ISOCEIMENAL LINES.** (Greek, *isos*, equal; *cheima*, winter.) Lines drawn on a globe or map of the world to connect places that have the same average winter temperature.
- ISOTHERAL LINES.** (Greek, *isos*, equal; *theros*, summer.) Lines drawn on a globe or map of the world to connect places that have the same average summer temperature.
- ISOTHERMAL LINES.** (Greek, *isos*, equal; *thermē*, heat.) Lines drawn on a globe or map of the world to connect those places on the earth that have the same average annual temperature, or on which the same quantity of heat is annually received from the sun.
- ISTHMUS.** A narrow neck of land connecting a continent or large island with some projecting headland.
- KAIM, or KAME.** The Scottish name for flat-topped gravel hills, called *osar* in Sweden, and *escars* in Ireland.
- KAROO.** A local name for certain clayey flat plains in South Africa, some low, some elevated, barren during part of the year, but covered with vegetation after rain.
- KITCHEN-MIDDENS.** (Danish *Kjokken-mødding*.) Heaps of shells, bones, and other waste from old habitations where dwelt the ancient tribes who inhabited parts of Northern Europe before the historic period.
- KNOTS, in mountain chains.** Portions of a chain where several spurs or branches of the principal chain unite and form a small plateau or

- elevated plain, sometimes many thousand feet above the sea. The Andes are remarkable for these knots.
- LAGOON.** A pool or lake of shallow water, generally salt.
- LAKE-DWELLINGS.** The remains of villages built on lakes in Switzerland, Ireland, and elsewhere, during the pre-historic period in Europe.
- LAND BREEZE.** See p. 97.
- LAND-LOCKED.** Portions of the ocean partially enclosed by chains of islands, are said to be land-locked.
- LANDES.** (French.) Extensive tracts of sand stretching between the Garonne and the Pyrenees, on the shores of the Bay of Biscay. They are now planted with the sea-pine and other pines.
- LANDSLIP.** A portion of a hill or mountain that has slid down into lower ground, owing generally to the infiltration of rain and the action of frost. Landslips are occasionally produced or assisted by earthquake shocks.
- LATITUDE.** (Latin, *latitudo*, breadth.) See p. 17.
- LEEWARD.** A nautical term, occasionally used in geography, and meaning that side of a ship or coast facing the direction of the prevalent wind. A coast-line that is exposed to prevalent winds is called a lee-shore. Thus, in the West Indies, the group of islands from Dominica to the Virgin Islands are called "the Leeward Islands," as facing the north-east, the point from which the trade wind blows.
- LICK.** An American term for the ground saturated with brine in the neighbourhood of saline springs. The cattle and wild animals frequent these swamps to lick the salt incrusted on the land and plants.
- LITTORAL.** (Latin, *littus*, the shore.) Belonging to the shore.
- LLANOS.** (Spanish, plains.) Extensive plains in South America, partly covered with forest trees, and watered by the river Amazon. One portion is treeless, others are barren, and some are grassy.
- LOAM.** A soil consisting of an admixture of clay, sand, and vegetable mould. Loams vary according to the preponderance of one member.
- LOGAN STONE.** The name given in Cornwall to a stone naturally so nicely balanced on three points that it can be easily moved, though not displaced without extreme difficulty.
- LONGITUDE.** (Latin, *longitudo*, length.) See p. 17.
- LUNAR.** (Latin, *luna*, the moon.) Relating to the moon.
- MAGNETIC EQUATOR and POLES.** A magnetic current circulates round the earth continually, but the magnetic poles, or extremities of the axis round which it circulates, do not correspond with the poles of the axis of rotation of the earth (called the north and south poles), and therefore, also, the magnetic equator does not correspond with the earth's equator. There are two magnetic poles, or rather a space near each pole of the earth where the compass needle dips down towards the earth's centre. There is also a line round the earth where the needle does not dip or incline downwards at all. This is the magnetic equator.
- MAGNETIC STORM.** A storm during which there is an interruption of the currents of earth-magnetism, that pass continually from pole to pole. Such storms are often coincident with great wind storms, and also with changes that take place in the body of the sun.
- MAMMALIA.** (Latin, *mamma*, a teat.) Animals that suckle their young.
- MARL.** A soil in which clay is sufficiently mixed with lime to render it friable.
- MARSUPIAL.** (Latin, *marsupium*, a pouch.) A group of quadrupeds, distinguished from all others by the possession of a loose pouch in the female, intended to receive and carry the young for some time after birth. The native Australian quadrupeds are marsupial.
- MERIDIAN.** (Latin, *meridies*, noon.) An imaginary line drawn through any place on the earth, connecting it with the two poles, is said to

- be its meridian. When the sun crosses this imaginary line each day it is noon.
- METEORITES.** (Greek, *meteoros*, floating in the air.) Stones or masses of metal falling through the atmosphere to the earth, and apparently derived from fragmentary bodies in space coming within the earth's atmosphere.
- MIGRATE.** (Latin, *migro*.) To remove from one place to another. Animals who remove periodically from one country to another are called migratory.
- MIRAGE.** A singular effect of the refracting or bending of the rays of light that sometimes takes place when the air is greatly and irregularly heated. Objects at a distance are distorted, and pools of water are apparently seen on a desert of sand where no water exists.
- MISTRAL.** A cold north-east wind, affecting chiefly the valley of the Rhone, and the parts of France and Italy adjacent, and greatly influencing the climate of those countries.
- MONOCOTYLEDON.** (Greek, *monos*, one; *cotyledon*, seed-leaf.) Plants whose seeds do not split when the plant begins to grow. Such plants increase from within, and their leaves have parallel veins. They form a great natural group, of which palms and grasses are examples, and which are called either *monocotyledons* or *endogens*.
- MONSOONS.** Periodical winds blowing in the Indian Ocean and Australian and China seas, representing the trade winds of the Atlantic. Similar winds blow on the coast of Mexico. The monsoons blow on the north of the equator, from the north-east, from October to March (winter), and from the south-west from April to September (summer). In the southern hemisphere, they blow from the south-east from April to September (winter), and from the north-west from October to March (summer).
- MORAINE.** (French.) The stream of gravel and stones found on a glacier. These stones are derived from the weathering of the rocks above. They are distributed through the mass of the glacier, and are always visible owing to the gradual melting and disappearance of the snow and ice that form the glacier.
- MOYA.** (Spanish.) A name given to the black sulphurous mud discharged from mud volcanoes.
- NADIR.** (Arabic, down.) The point in the heavens directly below our feet, in opposition to the *Zenith* directly over head.
- NEAP TIDES.** See *TIDES*.
- NÉVÉ.** The name given in Switzerland to the unfrozen snow in the upper part of a glacier. The *névé* is the feeder of the glacier.
- NITROGEN.** (Greek, *nitron*, nitro; *ginomai*, to produce.) The name of a very important gas forming four-fifths of the atmosphere. The various compounds called nitric and nitrous acids, and nitrates of various kinds, are hence derived.
- NODULE.** A rounded or almond-shaped portion in the interior of a rock produced after the mass of the rock had been formed.
- NOMADIC.** (Greek, *nomas*, pasturing.) A name given to pastoral tribes, because, from the necessity of finding food for their flocks, they are constantly wandering. The term nomadic, therefore, is used in contradistinction to settled.
- NORMAL.** (Lat *n*, *normalis*, according to rule.) The normal state is the original condition of any individual or natural group that has undergone change or domestication.
- NUCLEUS.** (Latin.) A central atom or substance round which other atoms of the same substance collect.
- NULLAH.** A Hindoo term for watercourses in table lands. Such watercourses are usually in ravines, dry, or nearly so, a great part of the year, but occasionally they carry down torrents. The Arabic term *Wadi* has the same meaning.
- OASIS.** A small cultivated spot in a desert. The cause of an oasis is

- generally the presence of a spring. Oases generally contain a few palm-trees and some other vegetation.
- OAZE, or OOZE.** The soft slimy tenacious mud, almost entirely of organic origin, found at the bottom of deep water in the open ocean.
- OBLATE.** Flattened at the poles. The figure of the earth is generally described as an oblate spheroid, a body nearly a sphere, but having a greater diameter at the equator than at the poles.
- ORBIT.** (Latin, *orbis*, a circuit.) The course or path of a body revolving round another.
- ORGANIC BEINGS.** Plants or animals, these being living things that possess what is called "organization."
- ORGANIC REMAINS.** The remains (showing the structure) of any plant or animal found fossil.
- OROGRAPHY.** (Greek, *oros*, a mountain; *graphie*, an account.) The department of physical geography that treats of mountains and mountain systems.
- OS, plural, OSAR.** (Swedish.) Long low flat-topped hills of gravel, very common in Sweden, and found also in the British islands. They are results of ice action. They generally consist of stones and sand, and one side (that towards the north) is a gentle slope, the other more or less scarped. They are called *Kaems* in Scotland, and *Escars* in Ireland.
- OXYGEN.** (Greek, *oxys*, sharp, or acid; *ginomai*, to produce.) The name of the substance most widely extended and most essential on the earth. The name is derived from the fact that almost all acids contain this gas as an essential ingredient.
- PACK-ICE.** Ice formed in the Polar seas by the freezing of salt water. Such ice is sometimes drifted into warm latitudes by marine currents.
- PAMPAS.** Vast treeless plains in South America, partly pastoral, partly agricultural. Millions of horses and cattle are fed on these plains. The northern part is crossed by rivers, but there are none in the south. There are many shallow pools of salt water on these plains.
- PAMPERO.** (Portuguese.) A storm wind of the nature of the cyclone occasionally blowing across the Pampas of Brazil, whence its name.
- PELAGIC ISLANDS.** (Gr. *pelagos*, the sea.) Islands in an open ocean. The South Sea Islands are of this kind.
- PENINSULA.** (Latin, *penes*, almost; *insula*, an island.) A considerable tract of land projecting from a large island or continent.
- PEPERINO.** (Italian.) A kind of natural cement of volcanic ash, sand, and cinder.
- PERMEABLE.** (Latin, *per*, through; *meo*, to pass.) Allowing water to pass through.
- PETROLEUM.** Mineral oil resembling naphtha, found sometimes in very large quantities in the earth, and much used for burning.
- PHENOMENON; Plural, Phenomena.** (Greek.) A natural appearance. A natural fact observed and studied. Thus the rainbow is a phenomenon. Rain itself is a phenomenon. The rising and setting of the sun, eclipses, &c., are astronomical phenomena.
- PHYSICS.** (Greek, *physis*, nature.) The science which considers and explains natural phenomena. The term is used in reference only to those phenomena which do not involve life. The phenomena of life are treated separately, and are considered to belong to natural history.
- PLATEAU; Plural, Plateaux.** A high table land. *See* TABLE LAND.
- PLUVIOMETER.** (Latin, *pluvius*, rain; *metron*, a measure.)
- POLES of the earth.** The extremities of the imaginary axis on which the earth revolves. *See* p. 3.
- PORTAGE.** (French.) The distance between the extreme ends of the navigable waters of two watersheds, or between the upper termination of two navigable streams of the same watershed. Sometimes the name is given to the interval between two navigable parts of a stream separated by waterfalls or rapids.

- PRAIRIE.** (American.) Very extensive tracts of rolling or hilly ground in North America, for the most part grassy and easily cultivable. See p. 48.
- PUMICE.** (Italian.) A peculiarly light stone, very spongy in texture, and consisting of lava so porous as to float on water. It is a volcanic product.
- QUADRUMANA.** (Latin, *quatuor*, four; *manus*, a hand.) Four-handed animals. The monkey tribe.
- QUADRUPED.** (Latin, *quatuor*, four; *pes*, a foot.) Four-footed animals.
- RADIATION.** The passage of particles of matter or forms of force, such as light or heat, from a body when the passage takes place in every direction at once. Thus a star radiates light, and a red hot cinder radiates heat.
- RAPIDS.** Portions of a river course where, in consequence of a sudden descent of the bed of the river, the water acquires a greatly increased velocity. The bed, under these circumstances, is generally covered by rocks, which break the water into foam, and render navigation difficult or impossible.
- RAVINE.** A narrow mountain valley.
- REEF.** A ridge or ledge of submarine rock rising nearly to the water's edge.
- REPRESENTATIVE SPECIES.** Species of plants or animals in distant countries having similar climates which perform the same or a corresponding part in nature. Thus the puma of South America represents the lion of the Old World, and the llama the camel.
- RIVER BASIN and RIVER SYSTEM.** The whole extent of country that supplies the water running into the sea by a single river and its tributaries.
- ROCHES MOUTONNÉES.** (French.) Rocks rounded and smoothed by the passage of ice over them.
- ROCK-BASINS.** Basin-shaped cavities in granite and other hard rocks, apparently produced by the action of rain and frost.
- ROCKING STONES.** See LOGAN STONES.
- SALSES.** (Italian.) Eruptions of hot mud, generally acid and saline, occasionally or continually issuing in certain districts at present, or formerly, volcanic. Inflammable gases occasionally accompany the eruption. They are also called mud volcanoes.
- SAND-DRIFT.** See DUNES.
- SAVANNAH.** Plains on the banks of the Mississippi covered at one time with long grass and a few trees, but now largely cultivated.
- SCAR.** (Saxon.) A steep or precipitous rock. Used in Yorkshire and Westmoreland with reference chiefly to the limestones.
- SCARPED.** Presenting a steep face. See ESCARPMENT.
- SCHIST.** A rock that splits readily but not regularly. Slates split with regularity, and are pure, or nearly pure, clay. Schists contain more sand and grit.
- SCIROCCO.** (Italian.) A hot south wind blowing over many parts of Europe. It is believed to proceed from the great desert of Africa, and cross first the Atlas mountains and then the Mediterranean sea. It has a peculiar effect on the human frame.
- SCORIAE.** (Latin, ashes.) The name given to the fragments of cellular lava forming at the top of a cooling mass proceeding from a volcano.
- SEA BREEZE.** A current of air setting in from the sea towards the land in tropical coasts. See p. 97.
- SEISMOLOGY.** (Greek, *seismos*, a shock; *logos*, a discourse.) The science of earthquake phenomena. *Seismometer* is an instrument to measure earthquake shocks.
- SHALE.** A variety of slate that consists of nearly pure clay, but which splits imperfectly.
- SHINGLE.** Rounded stones forming the gravel on the sea shore.
- SHOAL.** Shallow. The sea bottom rising nearly to the water level.
- SIERRA.** (Spanish.) A ridge; the name given to a short mountain range.

- SILT.** The fine impalpable mud deposited from water after the heavier sands and gravels have been left behind. Harbours are sometimes said to be *silted up*, or choked, by the accumulation of silt.
- SILVAS.** (Portuguese.) Wooded plains, forming a part of the Llanos, or great plains of the Amazon in South America. The forest comes to the water's edge, and the country is covered with the richest vegetation and crowded with animal life, but almost without human inhabitants.
- SIMOOM.** (Sometimes called *Samiel*.) The name of the hot storm wind from the desert that crosses Arabia.
- SINTER.** (German, *sintern*, to drop.) Compact incrustations, produced where water containing silica or carbonate of lime in solution has been allowed to evaporate slowly.
- SLATE.** A peculiar variety of clay rock, splitting into very thin and hard sheets or films.
- SNOW LINE** (sometimes called "limit of perpetual snow"). The limit of height at which snow is permanent throughout the year. Although in all cases, except in the tropics, the actual height varies from summer to winter, the mean or average height remains very nearly the same. It varies with latitude, the height being generally greatest at the equator and disappearing in the arctic circle; but there are some remarkable exceptions, especially in the Himalaya mountains.
- SOLANO.** (Spanish.) A hot south-west wind blowing from the desert across parts of Spain. It is a modified scirocco.
- SOLFATARA.** (Italian.) A crack in the earth whence proceeds occasionally or constantly a quantity of vapour of water, with which is mixed much carbonic acid gas and some sulphurous acid. Sulphur is sometimes deposited at the orifice whence the vapours issue. The smell of sulphur is very powerful.
- SPECIFIC CENTRES.** The parts of the earth from which, according to some naturalists, important species, or groups of species, took their origin, and whence they spread in every direction.
- SPHERE, SPHEROID.** (Greek.) The shape of a ball. A sphere is a solid whose surface is everywhere at the same distance from the central point. A spheroid is a solid not accurately spherical, but approaching and resembling a sphere. The earth is said to be an oblate spheroid, or a sphere flattened at two opposite points. It resembles in this respect an orange.
- SPOON-DRIFT.** A shower of broken salt water, derived from the crests of waves during violent storms at sea. The spray is carried up into and through the air with great rapidity, and at an extremely rapid rate.
- SPRING TIDES.** See **TIDE**.
- STALACTITE.** (Latin.) Stone formed in a cavern or cavity by the dripping of water from the roof, the water containing some mineral, as limestone or flint in solution, and the evaporation of part of the water taking place before the drop has fallen. In this way a kind of column is formed from the roof of the cavern. Sometimes thin sheets of stone are formed by a number of drops close together issuing from a narrow fissure.
- STALAGMITE.** (Latin.) Stone formed in a dripping cavern by the evaporation of the water containing limestone or flint on the floor after the drops have fallen. Stalagmites form on the floors of caverns beneath stalactites, and sometimes rise half way to meet them, and make a complete column.
- STEPPES.** The name given to the great plains of Eastern Europe and Western and Northern Asia. They are covered with vegetation during part of the year, and yield large crops under corn cultivation. (See p. 47.)
- STRATUM; Plural, Strata.** (Latin.) A bed or layer. Each layer of mud or sand deposited by water is called a *stratum*, and a number of layers together are called *strata*.

SUBAQUEOUS. Under water.

SUBMARINE. Under the surface of the waters of the ocean.

SURF. The broken water of waves rolling in from a large sea on comparatively flat shores, the retiring wave meeting the advancing wave, and thus producing a never-ceasing line of foam. The surf is especially dangerous near the shore of many islands in the Pacific Ocean.

SWAMP. Low flat marshy land. In America, the term is applied to flat lands with a few trees.

SYNCHRONOUS. (Greek, *syn*, together; *chronos*, time.) Occurring at the same time.

TABLE LAND, or PLATEAU. (Plural, *plateaux*.) A tract of high land, level or only interrupted by hills and intersected by ravines, and having a general elevation many hundred or thousand feet above the sea. Table lands differ from low plains chiefly by their average height above the sea. Thus the mean elevation of the table land of Spain is 2,000 feet, and of Thibet 15,000 feet. The elevation of low plains does not average so much as 200 feet.

TALUS. The natural slope produced by the falling away of the upper part of the steep face of a hill or escarpment.

TEBBAD. (Persian, fever-wind.) Hot sand winds crossing the plains of Central Asia.

THERMAL. (Greek, *thermé*, warm or hot.) Thermal springs are warm springs, or springs of warm water.

TIDE. A periodical movement of the ocean by which the water is constantly rising or falling, rising for seven hours and then falling about five hours, till it attains the former level of low water. The movement is originally caused by the moon's attraction, but the actual phenomena are very complicated. The great tide wave originates in the Pacific, where alone there is a large uninterrupted space of water. *Spring tides* are the extremely high and low tides occurring soon after new and full moon. *Neap tides* are the tides after the first and third quarter of the moon, when the amount of the tide is smallest.

TORNADO. See **CYCLONE**.

TRAVERTINE. A peculiar form of limestone produced when water charged with carbonate of lime is evaporated. It is very abundant in Italy, and forms sometimes a building stone. The particles of limestone often collect and arrange themselves during evaporation on some minute organic body.

TROPICS. (Greek, *trepo*, to turn.) The belt of land within 23° 28' from the equator, on both sides, within which the sun is sometimes vertical. When the sun has reached this distance from the equator, he appears to turn back.

TUNDRA. The low flat lands of Scandinavia and Northern Russia are thus called.

TYPE, TYPICAL. (Greek, *typos*, a form.) Among plants and animals, those species that represent what are regarded as the essential and characteristic peculiarities are called *types*, or typical forms.

TYPHOON. See **CYCLONE**.

UPLIEAVAL. The elevation of a part of the earth in consequence of some force thrusting up from below.

VARIABLES. The region near the equator, a little to the north of it, where the north-east and south-east trade winds meet, neutralize each other, and are replaced by calms and light winds.

VARIATION of the compass. The compass needle does not often point true north in any part of the world, and the difference between true north and compass north varies continually: this difference is the "variation of the compass." At present, in the south of England, it amounts to about 26°. The needle now points 26° west of true north, or nearly NNW. The annual change is very small, but tends to diminish the amount of the variation.

VOLCANO (Fulcanus, Vulcan). A conical hill or mountain, with a cup-

shaped depression at the top called a *crater*. From the crater, or from cracks in the side of the hill, steam, various gases, stones, and molten rock, pour out from time to time. The mountain is generally made up of the materials erupted, which have fallen back on the earth.

WARPING. An artificial process, in imitation of the natural one, by which water deposits, when it is detained in shallows, the mud it has brought down from the land.

WATER SHED or WATER PARTING. (German, *wasser*, water; *scheide*, parting.) The line drawn to connect the points that separate two adjacent drainage areas.

WATERSPOUT. A small circular storm of wind, during which large quantities of water are carried along through the air in a definite direction, and at last break or are dissipated, the water falling with extreme rapidity on a small area. A waterspout in motion looks like two cones placed point to point, and consists of two distinct parts which do not always move at precisely the same speed.

WAVE. The motion produced when a fluid or gas is disturbed. Owing to the nature of liquids and gases, motion is communicated to them gradually, and not at once. Thus is produced in fluids a heaving and sinking of the surface, extending for a long distance, and in gases, or the air, an alternate advance and retirement of large bodies of the gas. There are several kinds of wave motions, some involving a movement in space of large quantities of the substance set in motion, others merely producing a motion among the particles, without any advance or retirement at all.

WEATHERING. The destroying effect of rain and frost and of the other conditions of the air that affect the weather. By these causes exposed rocks are split, broken and carried away, and to them indeed the whole face of nature as we see it is due. Weathering is the final change induced on rocks, after they have been lifted up and exposed to water action.

WHIRLPOOL. A rotatory motion of water, produced generally by the meeting of strong currents coming from different directions. They are much less important now than when navigation was less understood.

WHIRLWIND. A revolving or rotatory storm. At sea a whirlwind produces a waterspout; on land, in a wide tract of sand, a sand storm. On a large scale in certain seas it becomes a cyclone.

WINDWARD. The sheltered side; the side or coast from which a prevalent wind blows. *See* **LEEWARD**.

ZENITH. (Arabic.) The point in the heavens vertically above the head of an observer. *See* **NADIR**.

ZODIAC. A belt or zone within which the apparent motions of the sun and planets are performed.

ZONE. A belt. The earth is divided into zones by ideal lines parallel to the equator. Nearest the equator, on each side, is the torrid zone. Nearest the poles are the frigid zones. Between the torrid and the frigid are the temperate zones.

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